Information on IAPMO Codes and Standards Development

1. **Applicable Regulations.** The primary rules governing the processing of the *Uniform Solar, Hydronics & Geothermal Code* and *Uniform Swimming Pool, Spa and Hot Tub Code* are the IAPMO Regulations Governing Consensus Development. Other applicable rules include the *Guide for the Conduct of Participants in the IAPMO Codes and Standards Development Process*. For copies of these documents, contact the Code Development Department at IAPMO World Headquarters at 4755 E. Philadelphia Street, Ontario, CA 91761-2816 USA, or at 909-472-4100. These documents are also available at the IAPMO website at [www.iapmo.org](http://www.iapmo.org).

   The following is general information on the IAPMO process. All participants, however, should refer to the actual rules and regulations for a full understanding of this process and for the criteria that govern participation.

2. **Technical Committee Report (TCR).** The Technical Committee Report is defined as “the Report of the Technical Committee, consisting of the Report on Proposals (ROP), as modified by the Report on Comments (ROC), published by the Association.”

3. **Report on Proposals (ROP).** The ROP is defined as “a report to the Association on the actions taken by Technical Committees, accompanied by a ballot statement and one or more proposals on text for a new Document or to amend an existing Document.” The ROP and the ROC together comprise the Technical Committee Report. Anyone who does not pursue an issue, either in person or by designated representative in accordance with Section 7.0 (Public Review and Comment of the Regulations Governing Consensus Development), as a proposed amendment of the Report on Proposals will be considered as having their objection resolved.

4. **Report on Comments (ROC).** The ROC is defined as “a report to the Association on the actions taken by Technical Committees, accompanied by a ballot statement and one or more comments resulting from public review of the Report on Proposals (ROP).” The ROP and the ROC together constitute the Technical Committee Report. Anyone who does not pursue an issue, either in person or by designated representative in accordance with Section 8.0 (Public Review and Comment of the Regulations Governing Consensus Development), as a proposed amendment of the Report on Comments will be considered as having their objection resolved.

5. **Appeals.** Anyone can appeal to the Executive Committee concerning procedural or substantive matters related to the development, content, or issuance of any Document of the Association or on matters within the purview of the authority of the Committee. Such appeals must be in written form and filed with the Secretariat (See 9.0 of the Regulations Governing Consensus Development). Time constraints for filing an appeal must be in accordance with Section 9.0. Objections are deemed to be resolved if not pursued at this level.

6. **Document Issuance.** The USHGC/USPSHTC Executive Committee is the issuer of the *Uniform Solar, Hydronics & Geothermal Code* and *Uniform Swimming Pool, Spa and Hot Tub Code*. The committee acts on the issuance of a Document within sixty days from the date of the recommendation from the ROC Technical Committee Meeting, unless this period is extended by the Executive Committee.
To: IAPMO Members and Other Interested Parties

Date: September 1, 2023

Enclosed is your 2023 Report on Comments (ROC). These comments were presented to the Solar, Hydronics and Geothermal Technical Committee who met on May 16, 2023.

Following the comments is a copy of how the 2024 edition of the Uniform Solar, Hydronics and Geothermal Code (pre-print) would appear if the Executive Committee accepts all committee actions.

This pre-print is provided to you as a courtesy. All changes are tentative and subject to revision. This document is not to be considered the final version of the 2024 Uniform Solar, Hydronics and Geothermal Code. Specific authorization from IAPMO is required for republication or quotation.
# 2024 Uniform Solar, Hydronics and Geothermal Code Technical Committee

(As of 06/20/22)

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<td>SunEarth (Fontana, CA)</td>
<td>Special Expert</td>
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<td>Michael Cudahy</td>
<td>Plastic Pipe and Fittings Association (Glen Ellyn, IL)</td>
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<td>Jacob Fear</td>
<td>TM Sales Inc. (Bozeman, MT)</td>
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<td>Research/Standards/Testing Laboratory</td>
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<td>Chris B. Haldiman</td>
<td>Watts Water Technologies (Springfield, MO)</td>
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<td>User</td>
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<td>IAPMO Staff</td>
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IAPMO Technical Committee Membership Application

IAPMO uses the information in this application to determine your qualifications and to assure that IAPMO technical committee appointments are made in a way that ensures that committees will contain a fair balance of interests. Please provide us with as much information as you feel will assist us in the selection process. Feel free to attach additional pages if necessary.

Name of Individual: ___________________________ Title: ___________________________
Employer: ____________________________________
Mailing Address: ____________________________________
UPS or Other Mailing Address: ____________________________________
City: ___________________________ State: ___________________________ Zip: ___________
Telephone: ___________________________ Fax: ___________________________ E-Mail: ___________________________

Please indicate committee for which you are applying:

☐ Plumbing Technical Committee
☐ Mechanical Technical Committee
☐ Swimming Pool, Spa and Hot Tub Technical Committee
☐ Solar, Hydronics and Geothermal Code Technical Committee
☐ Water Efficiency and Sanitation Standard Technical Committee

Member categories:

☐ Principal member
☐ Alternate member. If Alternate, to whom ___________________________
☐ Non-voting member

Please indicate the interest category (see definitions on page 2) which you believe best suits your qualifications:

☐ Manufacturer
☐ User
☐ Installer/Maintainer
☐ Labor
☐ Design Professional (WEStand only)
☐ Research/Standards/Testing Laboratory (N/A to WEStand)
☐ Enforcing Authority
☐ Consumer
☐ Special Expert

1. QUALIFICATIONS OF APPLICANT
   a. Provide evidence of your general knowledge and competence in the scope (work) of the committee (please attach résumé)

          ______________________________________________________
          ______________________________________________________
          ______________________________________________________
   b. What is your specific relationship to one or more elements of the scope of the committee?

          ______________________________________________________
          ______________________________________________________
          ______________________________________________________
   c. Will you be able to actively participate in the work of the committee including responding to correspondence and attending committee meetings?

          ______________________________________________________
          ______________________________________________________
          ______________________________________________________

2. REPRESENTATION
   a. Indicate below the name of the entity you would be representing and include written authorization from that entity authorizing you to be their representative:

          ______________________________________________________
          ______________________________________________________
          ______________________________________________________
   b. Does the organization you would represent have a mechanism for instructing votes? If so, can the time constraints imposed by the Regulations Governing Committee Projects be met?

          ______________________________________________________
          ______________________________________________________
          ______________________________________________________
3. **FUNDING SOURCE(S) FOR YOUR PARTICIPATION**
   a. What person(s) or organization(s) would fund your participation as a committee member, either in whole or in part? (You should list your employer if your participation is funded by your employer or if your participation is part of your employment responsibilities or otherwise related to your employment.)

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

   b. Background and description of your employer and/or other person(s) or organization(s) funding participation:

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

4. **ADDITIONAL COMMENTS**

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

Languages other than English ____________________________________________

COMPLETE A SEPARATE APPLICATION FORM FOR EACH COMMITTEE ON WHICH YOU DESIRE TO SERVE. IN ORDER TO ASSURE THE PROMPT PROCESSING OF YOUR REQUEST, PLEASE BE SURE TO COMPLETE ALL QUESTIONS AND SIGN THIS APPLICATION.

If appointed, I agree to abide by the rules and guidelines of IAPMO. In addition, I hereby agree to notify the Secretary of the IAPMO Standards Council of a change in status, including change of employment, organization represented, or funding source. I also agree that IAPMO shall have, and I hereby grant, all and full rights in copyright in any material that I author, either individually or with others, as a member of this committee, or that I submit for the proposed use of the committee in an IAPMO code or standard or other IAPMO document. I further acknowledge that I acquire no rights in any publication of IAPMO and that copyright and all rights in all materials produced by IAPMO technical committees are owned by IAPMO and that IAPMO may register copyright in its own name.

I do not now hold, and I do not intend to hold any patent, the use of which would be required for compliance with any material that I author – either individually or with others – as a member of this committee, or that I submit for the proposed use of the committee in an IAPMO code or standard or other IAPMO document.

I attest that all the information on this application is true and accurate.

By signing below, I attest to my ability to communicate with IAPMO staff and the members of the Technical Committee through electronic means, namely via email and the internet.

Signature __________________________________________
Date___________________________

**INTEREST CATEGORIES**

(a) **Manufacturer.** A representative of a maker or marketer of a product, assembly or system, or portion thereof that is affected by the document.

(b) **User.** A representative of an entity that is subject to the provisions of the Document or that voluntarily uses the Document.

(c) **Installer/Maintainer.** A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the Document.

(d) **Labor.** A labor representative or employee concerned with safety in the workplace within the scope of the Document.

(e) **Research/Standards/Testing Laboratory.** A representative of an independent research organization; an organization that develops codes, standards and other similar documents; or an independent testing laboratory.

(f) **Enforcing Authority.** A representative of an agency or an organization that promulgates or enforces the Document.

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(h) **Special Expert.** A person not representing (a) through (g) and who has special expertise in the scope of the Document or portion thereof.

(i) **Design Professional.** A person who is in the business of designing systems affected by the Document.
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USHGC•USPSHTC Technical Correlating Committee Report

Geothermal Energy Systems Task Group Report

Hydronics Systems Task Group Report

2023 Uniform Solar, Hydronics and Geothermal Code Preprint

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International Association of Plumbing and Mechanical Officials
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Proposals

Item #: 004

USHGC 2024  Section: 204.0

SUBMITTER: Jazmin Curiel
Self

RECOMMENDATION:
Revise text

204.0  – B –
Balancing Valves. A valve that regulates the flow rate of liquid, to achieve uniform distribution, throughout multiple collectors, heat sources, circuits, or emitters.

SUBSTANTIATION:
The definition for “balancing valves” is being updated to explain that these valves also regulate flow and achieve uniform distribution throughout heat sources, circuits, and emitters, rather than just through multiple collectors. This language is also consistent with the mechanical code.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposal is being rejected as the additional language does not provide further clarity for inspectors or code officials. There is a concern with the term “circuit” and what its intent or definition is as the term can be confused with an electrical circuit. Additionally, the term “uniform” does not sufficiently identify the intent of the definition. The TC requests that the definition be revised and resubmitted as a public comment.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 204.0  Item #: 004

SUBMITTER: Jeff Matson  Chair, USHGC Hydronics Systems Task Group  Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

204.0  – B –
Balancing Valves. A valve that regulates the flow rate of a fluid-liquid, to achieve uniform distribution, throughout multiple collectors.
SUBSTANTIATION:
The definition of “balancing valve” is being revised for clarity and technical correctness. Balancing valves are flow regulators and are not used specifically for uniform distribution through collectors. The modified terminology removes improper specificity and clarifies that such valves allow you to design the system as intended rather than only for uniform distribution.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 007
USHGC 2024  Section: 205.0

SUBMITTER: Lee Stevens
LH Stevens Constructors LLC

RECOMMENDATION:
Revise text

205.0  C
Closed-Loop System. A hydronic system where the fluid is enclosed in a piping system that is not vented to the atmosphere; that uses a captive installed fluid mass that is circulated to transfer thermal energy between heat exchange sources and emitters installed on the system loop.

SUBSTANTIATION:
The current definition excludes all systems that incorporate an air separator with an automatic air vent, which is clearly not the intent of the code. This unintended exclusion results in all systems having an exception to water quality standards, if such standards are accepted to the code, as they can legitimately claim to be “open-loop.”

In standard engineering practice, "closed-loop" refers to a constant uid mass with no exchange of uid between the system and the environment in order to effect thermal energy exchange. The code is best served by maintaining that distinction in order to properly regulate the various system types.

Some form of venting is an essential component of virtually all closed-loop systems as the initial water charge carries some volume of entrained air or gases that must be vented out for satisfactory system performance and reduction of potential for oxidation of system components.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS:  AFFIRMATIVE: 4  NEGATIVE: 12

Note: Item # 007 failed to achieve the necessary two-thirds affirmative vote of returned ballots. In accordance with Section 6.8.2 of the Regulations Governing Consensus Development of the USHGC and USPSHTC, a public comment is requested for this proposal. The Technical Committee will reconsider this proposal as a public comment.

EXPLANATION OF AFFIRMATIVE:
FECTEAU: I agree with Lance MacNevin’s comment of fixing this with a public comment. However, moving this forward at this stage of the process in accordance with the committee action.

EXPLANATION OF NEGATIVE:
CHRISMAN: This new definition is technically correct, but it excludes a portion of the previous definition that is also important. I think we should fix this through public comment.

CUDAHY: I agree with Lance MacNevin’s comment.

FEAR: The definition as written is too exclusive. Let’s correct through public comment.
HALDIMAN: This definition is technically correct, but it excludes a portion of the previous definition that is also important. This should be fixed through public comment.

KEMPER: I agree with Lance MacNevin.

KREITENBERG: This definition is technically correct, but it excludes a portion of the previous definition that is also important. This should be fixed through public comment.

MACK: I am with Lance MacNevin’s comment.

MACNEVIN: This new definition is technically correct, but it excludes a portion of the previous definition that is also important. I think we should fix this through public comment.

MURRAY: I agree with Lance MacNevin’s comment.

REVANKAR: I agree with Lance MacNevin’s comment.

RODRIGUEZ: The definition is incomplete and should be fixed in public comment.

SMITH: I agree with Lance MacNevin’s comment.

---

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 210.0

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

210.0 – H –

Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

Hydronic System, Closed-Loop System. A hydronic system where the fluid is enclosed in a piping system that is not vented to the atmosphere in which a captive fluid is circulated to transfer thermal energy between heat exchange sources and emitters installed on the system loop.

SUBSTANTIATION:
The definition of “closed-loop system” is being revised to “closed-loop hydronic system” in order to more appropriately align with the scope of the USHGC. The existing terminology references “piping system[s] that [are] not vented,” and this is not a true characteristic of a closed-loop. The appropriate description is “captive fluid” as shown in the proposed modification.

Additionally, language has been included which clarifies that this captive fluid is circulated to transfer thermal energy between the heat sources and emitters. Such revisions are also inline with the other definitions proposed by this Task Group pertaining to “atmospheric closed-loop hydronic system” and “non-oxygen barrier closed-loop hydronic system.” (See Item #40 Public Comment 2.) The combination of these three definitions provides a better overall understanding of the variations within closed-loop hydronic systems.

COMMITTEE ACTION: REJECT
COMMITTEE STATEMENT:
Item #007 Public Comment 01 though Public Comment 03 were heard and discussed together. The committee agrees with the definition for “closed-loop hydronic system” presented in Item #007 Public Comment 03 as it correlates with the Uniform Mechanical Code, offers a more complete technical description, and aligns more appropriately with the intent of the USHGC. For this reason, Item #007 Public Comment 01 is being rejected.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2
Code Year: 2024 USHGC  Section #: 210.0

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

210.0  - H -
Hydronic System. Relating to or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

Hydronic System, Geothermal Closed-Loop. A hydronic system that uses a captive fluid to recirculate between one or more heat exchangers submerged in a body of water or buried in the ground, fluidly coupled to one or more heat exchangers or heat pumps serving one or more conditioned spaces or thermal storage vessels.

SUBSTANTIATION:
The Geothermal Energy Systems Task Group is aware of the recommendation submitted by the Hydronics Systems Task Group which provides a clear definition for “closed-loop hydronic system” and wishes to further align with the intent to relocate all hydronic systems types under the main definition for “hydronic system.”

As the definition for “closed-loop system” is being revised to “closed-loop hydronic system,” a definition for “geothermal closed-loop hydronic system” is needed to address geothermal systems that fall under this category.

As geothermal systems are an extension, or type, of hydronic systems, it is logical and appropriate to relocate the definition as proposed.

The provided terminology is descriptive and clearly dictates that a geothermal closed-loop system is a type of hydronic system that is submerged and uses a captive fluid for heat transfer.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #007 Public Comment 01 though Public Comment 03 were heard and discussed together. The committee agrees with the definition for “geothermal closed-loop hydronic system” presented in Item #007 Public Comment 03 as it correlates with the Uniform Mechanical Code, offers a more complete technical description, and aligns more appropriately with the intent of the USHGC. For this reason, Item #007 Public Comment 02 is being rejected.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
PUBLIC COMMENT 3

Code Year: 2024 USHGC  Section #: 210.0  Item #: 007
SUBMITTER: Jazmin Curiel  Self  Comment #: 3

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

210.0  – H –  Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

Hydronic System, Closed-Loop System. A hydronic system where the fluid is enclosed in a piping system that is not vented to the atmosphere that uses a captive installed fluid mass that is circulated to transfer thermal energy between heat exchange sources and emitters installed on the system loop.

Hydronic System, Geothermal Closed-Loop. A closed-loop hydronic geothermal system that uses one or more heat exchangers submerged in a body of water or buried in the ground, fluidly coupled to one or more heat exchangers or heat pumps serving one or more conditioned spaces or thermal storage vessels.

SUBSTANTIATION:
The proposed change relocates the definition of “closed-loop system” and updates the title to “closed-loop hydronic system.” The existing language already states that it is a type of hydronic system and should therefore be relocated under the main term “hydronic system” within Chapter 2. A new definition for “geothermal closed-loop hydronic system” is also being proposed to cover geothermal systems which fall under this category and are not yet clearly defined. Since geothermal systems are a subset of hydronic systems, this location is appropriate. The provided terminology was gathered from accepted Item #306 Public Comment 2 as published in the 2022 UMC Report on Comments.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16
Proposals

Item #: 010
USHGC 2024  Section: 207.0

SUBMITTER: Jazmin Curiel
Self

RECOMMENDATION:
Revise text

207.0  —  E —
Expansion Tank. A vessel installed in a system to provide a pneumatic cushion for the expansion of fluid protect closed systems from excessive pressure.

SUBSTANTIATION:
The definition is being modified to specifically state that the purpose of expansion tanks is to protect closed systems from excessive pressures. The previous definition was too broad and not clear enough for the purposes of the USHGC.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language stating “to protect closed systems from excessive pressure” is more inline with the definition of a pressure relief valve and does not belong in the definition for an expansion tank. The terminology for expansion tank should specify cushion for thermal expansion and contraction.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 207.0
SUBMITTER: Jim Majerowicz
Plumbers Local Union 130 U.A.

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

207.0  —  E —
Expansion Tank. A vessel installed in a system used to protect closed systems from excessive pressure to provide a pneumatic cushion for the expansion of fluid.
SUBSTANTIATION:
This code change is for correlation with the Uniform Mechanical Code. Expansion tanks serve as a means of system protection from excessive pressures. These tanks are designed to relieve pressure in both potable water and closed hydronic heating systems, and the proposed definition accurately describes this purpose.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #010 Public Comment 01 and Public Comment 02 were heard and discussed together. The committee prefers the definition for “expansion tank” presented in Public Comment 02 as it specifies that the purpose of an expansion tank is to "accommodate the thermal expansion and contraction of the system fluid.” The committee agrees that such distinction is necessary within the technical description for “expansion tank.” Additionally, the proposed definition in Public Comment 01 offers a general description which is very similar to the original proposal, and the committee references their original committee statement for rejecting Item #10 as still being relevant.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2

Code Year: 2024 USHGC   Section #: 207.0
Item #: 010

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

Comment #: 2

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

207.0 – E –
Expansion Tank. A vessel installed in a system to accommodate the thermal expansion and contraction of the system fluid provide a pneumatic cushion for the expansion of fluid.

SUBSTANTIATION:
The definition of “expansion tank” is being updated to remove overly specific language pertaining to “pneumatic cushion,” which is not a defining characteristic but rather one subset of expansion tanks. The new language is more general and encompasses the overall purpose of these tanks which is to accommodate thermal expansion and contraction of system fluid.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 012
USHGC 2024  Section: 209.0

SUBMITTER: Jim Majerowicz
Plumbers Local Union 130 U.A.

RECOMMENDATION:
Add new text

209.0 – G –
Groundwater. Water that exists beneath the earth’s surface.

SUBSTANTIATION:
The term “groundwater” is used throughout Chapter 7 (Geothermal Energy Systems) and is not supported by a current definition. Since the reference to groundwater is also within the applicability section of Chapter 7, it is necessary to provide such terminology for users of the code. Additionally, the language correlates with the mechanical code.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

EXPLANATION OF AFFIRMATIVE:

MACNEVIN: NGWA definition: "Groundwater is the water that soaks into the soil from rain or other precipitation and moves downward to fill cracks and other openings in beds of rocks and sand."

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Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 209.0  Item #: 012
SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group  Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

209.0 – G –
Groundwater. Water that exists beneath the earth’s surface which is differentiated from surface water in that it is not exposed to the atmosphere.
The existing definition for “groundwater” is vague and may lead to misinterpretation as not all water beneath the earth’s surface is considered groundwater. For this reason, language has been added to make this distinction and clarify that groundwater is water beneath the earth’s surface and is not exposed to the atmosphere.

**COMMITTEE ACTION: REJECT**

**COMMITTEE STATEMENT:**
Item #012 Public Comment 01 is being rejected as the committee prefers the definition for “groundwater” which was accepted during the proposal stage. The original definition offers a simple and clear description that aligns with the provisions of the USHCG and also correlates with the mechanical code.

**TOTAL ELIGIBLE TO VOTE: 16**

**VOTING RESULTS:** AFFIRMATIVE: 16

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**PUBLIC COMMENT 2**

**Code Year:** 2024 USHGC  **Section #:** 209.0

**SUBMITTER:** Jeff Persons  Self

**RECOMMENDATION:**
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

209.0 – G –

**Groundwater.** Water that exists beneath the earth’s surface in saturated zones beneath the land surface and may discharge to surface waters such as rivers, streams, lakes, ponds, and wetlands.

**SUBSTANTIATION:**
A more technical definition of “groundwater” would be beneficial to the USHGC. The original proposal failed to mention that groundwater is essentially in saturated zones beneath unsaturated soil, or the land surface. Including potential methods of discharge also gives needed details when understanding groundwater and its impact on the environment or its potential uses.

**COMMITTEE ACTION: REJECT**

**COMMITTEE STATEMENT:**
Item #012 Public Comment 02 is being rejected as the committee prefers the definition for “groundwater” which was accepted during the proposal stage. The original definition offers a simple and clear description that aligns with the provisions of the USHCG and also correlates with the mechanical code.

**TOTAL ELIGIBLE TO VOTE: 16**

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 015
USHGC 2024  Section: 217.0

SUBMITTER: Lee Stevens
  LH Stevens Constructors LLC

RECOMMENDATION:
Revise text

217.0  – O –
Open-Loop System. A hydronic system where the fluid is enclosed in a piping system that is vented to the atmosphere, that takes in a fluid mass from an external source, transfers thermal energy into or out of the fluid by means of one or more heat exchangers, and then returns the fluid mass all or in part to the external source.

SUBSTANTIATION:
The current definition includes all hydronic systems that incorporate an air separator with an automatic air vent, which is clearly not the intent of the code. Some form of venting is an essential component of virtually all closed-loop systems, as the initial water charge carries some volume of entrained air or gases that must be vented out for satisfactory system performance and reduction of potential for oxidation of system components. This unintended inclusion results in all systems having an exception to water quality standards, if such standards are accepted to the code, as they can legitimately claim to be "open-loop."

In standard engineering practice, "open-loop" refers to a system wherein fluid mass is brought into the system from an external source, thermal energy is added to or removed from that fluid mass by means of heat exchange devices installed in the system, and then the fluid is returned to the external source. Fluid mass transfer to effect thermal energy transfer is the sole essential characteristic of an open-loop system. The code is best served by maintaining that distinction in order to properly regulate the various system types.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

217.0  – O –
Open-Loop System. A hydronic system that takes in a fluid mass from an external source, transfers thermal energy into or out of the fluid by means of one or more heat exchangers, and then returns the fluid mass all or in part to the external source.

COMMITTEE STATEMENT:
The Technical Committee requested that the term "the" be editorially updated to "an" to clarify that more than a single external source may be utilized or connected to the system.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 3  NEGATIVE: 13

Note: Item # 015 failed to achieve the necessary two-thirds affirmative vote of returned ballots. In accordance with Section 6.8.2 of the Regulations Governing Consensus Development of the USHGC and USPSHTC, a public comment is requested for this proposal. The Technical Committee will reconsider this proposal as a public comment.

11
EXPLANATION OF AFFIRMATIVE:

FECTEAU: Supporting the committee action. If this needs additional clarification, let it be done via a public comment for the committee to review.

EXPLANATION OF NEGATIVE:

CHRISMAN: Needs to be edited in public comment.

CUDAHY: Reject and further edit via a public comment.

FEAR: Editing is required.

HALDIMAN: Proposed language "that takes in" needs clarification. This can be corrected in the Public Comment process.

KEMPER: Needs further clarification. Should go back for public comments.

KREITENBERG: Requires public comment.

MACK: Needs to be edited in public comment.

MACNEVIN: The new definition says that fluid is from "an external source", but this is not always the case, and may be a confusing term. An open loop system can also utilize fluid from an internal source (e.g., heat pump). This should be revised through public comment.

MATSON: Should be rejected and further edited via Public Comment.

MURRAY: Needs to go to public comment.

REVANKAR: Reject and edit via public comment.

RODRIGUEZ: Fix in public comment.

SMITH: Needs to go to public comment.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 210.0, 217.0  
SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

217.0 - O -
Open-Loop System. A system where the fluid is enclosed in a piping system that is vented to the atmosphere.

210.0 - H -
Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

Hydronic System, Geothermal Open-Loop. A hydronic system that derives its source of fluid heat exchange from surface water, ground water, or commercial/industrial process water/fluid. After its use, the heat exchange fluid is discharged back to its source or to the environment.
SUBSTANTIATION:
In conjunction with the recommendation provided by the Geothermal Energy Systems Task Group for Item #007, the intent of this public comment is to relocate all hydronic system types under the main definition for “hydronic system.” As geothermal systems are an extension, or type, of hydronic systems, it is logical and appropriate to relocate the definition as proposed. As the recommendation by the Hydronics Systems Task Group in Item #007 essentially removes or replaces the definition for “closed-loop system,” the definition for “open-loop system” should also be removed.

The provided terminology clarifies that a geothermal open-loop system is a type of hydronic system, dictates sources for heat transfer fluids, and describes where the heat transfer fluid is discharged after use. The inclusion of this definition is necessary as it offers a better understanding of such systems when interpreting and implementing requirements laid out in Part III (Open-Loop Systems) of Chapter 7 (Geothermal Energy Systems).

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #015 Public Comment 01 and Public Comment 02 were heard and discussed together. The committee agrees with the definition for “geothermal open-loop hydronic system” presented in Public Comment 02 as it correlates with the Uniform Mechanical Code, offers a more complete technical description, and aligns more appropriately with the intent of the USHGC. For this reason, Item #015 Public Comment 01 is being rejected.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2
Code Year: 2024 USHGC  Section #: 210.0
SUBMITTER: Jazmin Curiel
Self
RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

210.0 – H –
Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

- **Hydronic System, Geothermal Open-Loop.** An open loop geothermal energy system draws in surface or ground water, passes it through one or more heat exchangers and/or heat pumps, and then discharges the water back into the environment.
- **Hydronic System, Open-Loop System.** A hydronic system where the fluid is enclosed in a piping system that is vented to the atmosphere that takes in a fluid mass from an external source, transfers thermal energy into or out of the fluid by means of one or more heat exchangers, and then returns the fluid mass all or in part to an external source.

SUBSTANTIATION:
The proposed change relocates the definition of “open-loop system” and updates the title to “open-loop hydronic system.” The existing language already states that it is a type of hydronic system and should therefore be relocated under the main term “hydronic system” within Chapter 2.

A new definition for “geothermal open-loop hydronic system” is also being proposed to cover geothermal systems which fall under this category and are not yet clearly defined. Since geothermal systems are a subset of hydronic systems, this location is appropriate. The provided terminology was gathered from accepted Item #309 Public Comment 2 as published in the 2022 UMC Report on Comments.
COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 017
USHGC 2024  Section: 304.3.4, 304.4.5, 304.4.6

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

RECOMMENDATION:
Revise text

304.0 Accessibility for Service.

304.3 Appliances in Attics and Under-Floor Spaces. (remaining text unchanged)

304.3.4 Lighting and Convenience Outlet. A permanent 120V receptacle outlet and a lighting fixture luminaire shall be installed near the appliance. The switch controlling the lighting fixture luminaire shall be located at the entrance to the passageway. [NFPA 54:9.5.3]

304.4 Appliances on Roofs. (remaining text unchanged)

304.4.5 Electrical Power. All appliances requiring an external source of electrical power for its operation shall be installed in accordance with NFPA 70, provided with the following:
1. A readily accessible electrical disconnecting means within sight of the appliance that completely de-energizes the appliance.
2. A 120V ac grounding-type receptacle outlet on the roof adjacent to the appliance on the supply side of the disconnect switch. [NFPA 54:9.4.2.3]

304.4.6 Platform or Walkway. Where water stands on the roof at the appliance or in the passageways to the appliance, or where the roof is of a design having a water seal, a suitable platform, walkway, or both shall be provided above the waterline. Such platform(s) or walkway(s) shall be located adjacent to the appliance and control panels so that the appliance can be safely serviced where water stands on the roof. [NFPA 54:9.4.2.4]

Note: NFPA 70 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:
The above section is being revised to correlate with NFPA 54-2021 (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).

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments
PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 304.1  Item #: 017
SUBMITTER: Jim Majerowicz  Plumbers Local Union 130 U.A.

RECOMMENDATION: Accept as Modified

Request to accept the code change proposal as modified by this public comment.

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 for repair or replacement of the appliance. Sufficient clearance shall be maintained to permit removal of the appliance; 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-in accordance with Section 304.3. [(NFPA 54:9.2.1)]

Exception: A platform shall not be required for unit heaters or room heaters.

(below shown for information purposes only)

304.3 Appliances in Attics and Under-Floor Spaces. An attic or under floor space in which an appliance is installed shall be accessible through an opening and passageway not less than the largest component of the appliance, and not less than 22 inches by 30 inches (559 mm by 762 mm).

SUBSTANTIATION:
This code change is for correlation with the Uniform Mechanical Code. The proposed change is a cleanup of the language in Section 304.1 (General). In particular, the term “sufficient” is being removed as it is poor code language.

The other revisions address access requirements for repair, removal, and replacement of appliances. Reference to Section 304.3 (Appliances in Attics and Under-Floor Spaces) is necessary as it offers additional requirements other than that the passageway must be floored.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2

Code Year: 2024 USHGC  Section #: 304.2.1  Item #: 017
SUBMITTER: IAPMO Staff - Update Extracts  NFPA 54 - Extract Update

RECOMMENDATION: Accept as Modified
Request to accept the code change proposal as modified by this public comment.

### 304.0 Accessibility for Service.

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

**304.2.1 Access.** Buildings exceeding of more than 15 feet (4572 mm) in height shall have an inside means of access to the roof, unless other means acceptable to the Authority Having Jurisdiction are used.

**Exception:** In Group R occupancies of less than 6 dwelling units and Group U occupancies. [NFPA 54:9.4.3.2]

**Substantiation:**
The above section is being revised to correlate with NFPA 54-2021 (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).

**Committee Action:**Accept as Submitted

**Total Eligible to Vote:** 16

**Voting Results:** Affirmative: 16

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**Public Comment 3**

**Code Year:** 2024 USHGC  **Section #:** 304.3.1

**Submitter:** Jim Majerowicz

Plumbers Local Union 130 U.A.

**Recommendation:**
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

### 304.3 Accessibility for Service.

**304.3 Appliances in Attics and Under-Floor Spaces.** (remaining text unchanged)

**304.3.1 Length of Passageway.** Where the height of the passageway is less than 6 feet (1829 mm), the distance from the passageway access to the appliance shall not exceed 20 feet (6096 mm) measured along the centerline of the passageway. [NFPA 54:9.5.1.1] Where the height of the passageway is 6 feet (1829 mm) or more, the distance from the passageway access to the appliance shall not exceed 50 feet (15 240 mm) measured along the centerline of the passageway.

**Substantiation:**
This code change is for correlation with the Uniform Mechanical Code. The proposed changes to Section 304.3.1 (Length of Passageway) are needed to limit the length of passageways which are 6 feet in height or more. The current language provides no limit or provisions for such passageways, and this requirement is necessary to prevent conflict with the building/residential codes.

**Committee Action:** Accept as Submitted

**Total Eligible to Vote:** 16

**Voting Results:** Affirmative: 16
Proposals

Item #: 018
USHGC 2024  Section: 310.2

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

310.0 Circulators and Pumps.

310.2 Mounting. The circulator or pump shall be installed in such a way that strain from the piping is not transferred to the circulator or pump housing. The circulator or pump shall be permitted to be directly connected to the piping, provided the piping is supported on each side of the circulator or pump. Where the installation of a circulator or pump will cause strain on the piping, the circulator or pump shall be installed on a mounting bracket or base plate or securely fastened to or supported by the structure. Where means for controlling vibration of a circulator or pump is required, an approved means for support and restraint shall be provided.

SUBSTANTIATION:
Section 310.2 is being updated to include additional installation options for circulators and pumps. These changes also prevent the language from being overly restrictive.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 310.2  Item #: 018
SUBMITTER: Arnold Rodio
Chair, USHGC-USPSHTC Technical Correlating Committee

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

310.0 Circulators and Pumps.

310.2 Mounting. The circulator or pump shall be installed in such a way that strain from the piping is not transferred to the circulator or pump housing. The circulator or pump shall be permitted to be directly connected to the piping, provided the piping is supported on each side of the circulator or pump. Where the installation of a circulator or pump will cause strain on the piping, the circulator or pump shall be installed on a mounting bracket or base plate, or securely fastened to or supported by the structure with approved fastening devices. Where means for controlling vibration of a circulator or pump is required, an approved means for support and restraint shall be provided.
SUBSTANTIATION:
The USHGC-USPSHTC TCC has generated a recommendation for USHGC Item # 018, Section 310.2 (Mounting) to be submitted as a USHGC Public Comment for consideration at the next USHGC TC meeting. The recommendation includes an additional requirement to use approved fastening devices when mounting circulators and pumps. The language, as written, ensures that pumps and circulators are secured while allowing the installer to use the most appropriate option available. The USHGC-USPSHTC TCC recommendation correlates with the action taken by the UMC TC to “accept as submitted” Item #252 Comment 1 as published in the 2022 UMC Report on Comments.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Item #: 020
USHGC 2024  Section: Table 317.3

SUBMITTER: Lance MacNevin
Plastics Pipe Institute

RECOMMENDATION:
Add new text

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEX in support channel</td>
<td>Cold Expansion</td>
<td>¾ inch and smaller, 6 feet;</td>
<td>All sizes, 9 feet</td>
</tr>
<tr>
<td></td>
<td>Insert and Compression</td>
<td>1 inch, 8 feet;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 ¼ inches and larger, 10 feet</td>
<td></td>
</tr>
<tr>
<td>PE-RT in support</td>
<td>Cold Expansion</td>
<td>¾ inch and smaller, 6 feet;</td>
<td>All sizes, 9 feet</td>
</tr>
<tr>
<td>channel</td>
<td>Insert and Compression</td>
<td>1 inch, 8 feet;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 ¼ inches and larger, 10 feet</td>
<td></td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
This addition provides guidance for hanger spacing for PEX and PE-RT tubing materials when they are installed using a support channel. Support channels are factory-produced items designed to attach to PEX and PE-RT tubing for the purpose of adding rigidity and stiffness, reducing the spacing of hangers, and reducing thermal expansion. These same requirements were added into CSA B214 (Installation Code for Hydronic Heating Systems) in 2021.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: 203.0  Item #: 020
SUBMITTER: Jim Majerowicz
Plumbers Local Union 130 U.A.

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

203.0 – A –
Anchors. See Supports.

(below shown for information purposes only)

210.0 – H –
Hangers. See Supports.

221.0 – S –
Supports. Supports, hangers, and anchors are devices for properly supporting and securing pipe, fixtures, and equipment.

SUBSTANTIATION:
This code change is for correlation with the Uniform Mechanical Code. Since both “anchors” and “hangers” are listed within the definition of “supports” as being devices used for supporting and securing pipe, equipment, and fixtures, the additional reference within Chapter 2 (Definitions) for “anchors” and “hangers” redirecting users to the definition of “support,” may be useful.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2

Code Year: 2024 USHGC Section #: 317.1
SUBMITTER: Jim Majerowicz Plumbers Local Union 130 U.A.

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

317.0 Hangers and Supports.
317.1 General. Piping, tubing, appliances, and appurtenances shall be supported in accordance with this code, the manufacturer’s installation instructions, and in accordance with the Authority Having Jurisdiction. Seismic restraints shall be in accordance with the building code.

SUBSTANTIATION:
This code change is for correlation with the Uniform Mechanical Code. The public comment is adding new text to ensure that selection and installation of hangers and supports accounts for potential seismic loads. The building code includes necessary requirements for such restraints and should therefore be referenced in Section 317.1 (General).

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
PUBLIC COMMENT 3

**Code Year:** 2024 USHGC  **Section #:** 409.3  **Item #:** 020

**SUBMITTER:** Jim Majerowicz
Plumbers Local Union 130 U.A.

**Comment #:** 3

**RECOMMENDATION:**
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

**409.0 Materials.**

**409.3 Hangers and Supports.** Pipe and tubing shall be supported in accordance with Section 317.0 and Table 317.3. Equipment that is part of the piping system shall be provided with additional support in accordance with this code and manufacturer’s installation instructions. Radiant systems utilizing heat emission or transfer plates shall have a gap of at least ¼ inch (6.4 mm) between adjacent plates.

**SUBSTANTIATION:**
This code change is for correlation with the Uniform Mechanical Code. Heat transfer or emission plates conduct heat energy from the tubing and spread that energy out laterally across the plate. The lateral thermal transfer eliminates hot spots directly over the tubing and provides more consistent temperatures at the floor surface. The plates offer a medium by which conductive heat transfer can occur. Due to potential expansion of heat emission plates in under-floor or above-floor radiant systems, there must be a gap between adjacent plates of not less than ¼ of an inch to avoid unwanted contact. (See the diagram below for an example of heat emission plates installed in a radiant system.)

![Diagram of heat emission plates](https://www.zurn.com/media-library/web_documents/pdfs/zpm02101-pdf.aspx)


**COMMITTEE ACTION:** ACCEPT AS AMENDED BY THE TC

**409.0 Materials.**

**409.3 Hangers and Supports.** Pipe and tubing shall be supported in accordance with Section 317.0 and Table 317.3. Equipment that is part of the piping system shall be provided with additional support in accordance with this code and manufacturer’s installation instructions. Radiant systems utilizing heat emission or transfer plates shall have a gap of at least ¼ inch (6.4 mm) between adjacent plates, or in accordance with the manufacturer’s installation instructions.
COMMITTEE STATEMENT:
Item #020 Public Comment 03 is being modified to include reference to the manufacturer’s installation instructions to ensure that appropriate spacing is provided between heat emission or transfer plates. This modification is necessary since spacing or gaps between plates is dependent on both material selection and system design, and providing a minimum gap applicable to all installations is not suitable.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 021
USHGC 2024  Section: 206.0, 401.1

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

401.0 General.
401.1 Applicability. This chapter shall apply to hydronic piping systems that are part of heating, cooling, ventilation, refrigeration, and air conditioning systems. Such piping systems include steam, hot water, radiant heating and cooling, chilled water, steam condensate, condenser water, solar thermal systems, and ground source heat pump systems, snow and ice melt systems, ambient temperature loops (ATL), and district thermal energy loops. The regulations of this chapter shall govern the construction, location, and installation of hydronic piping systems.

206.0  D –
District Thermal Energy Loop. A closed-loop piping system with central pumping that includes various heat sources and heat sinks. The sources/sinks can be passive (e.g., a ground loop, a body of water, sewer effluent) or active (e.g., boiler, cooling tower, heat pumps, or chillers) and further can include opportunistic, or unique locally available waste or by-product heat sources (e.g., data center, industrial process). The loop may run exterior to conditioned spaces in order to serve multiple structures and the heat exchange devices installed within.

SUBSTANTIATION:
Section 401.1 (Applicability) is being updated to include the variations of hydronic systems which are addressed in this chapter and other portions of the code. District thermal energy loops are becoming more common in the industry and such emerging technologies should be included. To further support these changes and provide additional clarity, a definition for district thermal energy loop is being proposed.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: 401.1
SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

401.0 General.
401.1 Applicability. This chapter shall apply to hydronic piping systems that are part of heating, cooling, ventilation, refrigeration, and air conditioning systems. Such piping systems include steam, hot water, radiant heating and cooling, chilled water, steam condensate, condenser water, solar thermal systems, ground source heat pump systems, snow and ice melt systems, ambient temperature loops (ATL), and district thermal energy loops. The regulations of this chapter shall govern the construction, location, and installation of hydronic piping systems.

SUBSTANTIATION:
Section 401.1 (Applicability) is being revised to remove reference to "ambient temperature loops." Since ambient temperature loops are a subset or type of district thermal energy loops, this reference is redundant and unnecessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

APPENDIX E
RECOMMENDED CONFIGURATIONS FOR CLOSED-LOOP HYDRONIC SYSTEMS

E 101.0 General.
E 101.1 Applicability. This appendix provides recommended configurations for both residential and non-residential closed-loop hydronic heating and cooling systems.
E 101.2 Purpose. The recommended configurations serve as a means of maintaining quality of heat transfer fluids over the life of the system and optimizing the life of system components.

E 102.0 Near Boiler Piping Schematics.
E 102.1 Systems with Chemical Additives. See Figure E 102.1(1) for a recommended near boiler piping schematic of a closed-loop hydronic system with chemical additives. The air separator is located at the optimal point within the system. See Figure E 102.1(2) for a recommended near boiler piping schematic of a closed-loop hydronic system utilizing glycol as the heat transfer fluid.
FIGURE E 102.1(1)
NEAR BOILER PIPING SCHEMATIC – CHEMICAL ADDITIVES

Note: This configuration is not applicable to hydronic systems containing antifreeze on the load side of the system. [e.g. snow and ice melt systems (SIMS)]

FIGURE E 102.1(2)
NEAR BOILER PIPING SCHEMATIC – GLYCOL
**E 102.2 Systems without Chemical Additives.** See Figure E 102.2 for a recommended configuration for a closed-loop hydronic system without chemical additives. The air separator is located at the optimal point within the system.

**FIGURE E 102.2**

NEAR BOILER PIPING SCHEMATIC – NON-CHEMICAL

**SUBSTANTIATION:**
Appendix E (Recommended Configurations for Closed-Loop Hydronic Systems) includes schematics gathered from IAPMO/ANSI H1001.1 (Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems). I served as Chair of the committee that developed this standard, and extensive discussion and review of this topic was conducted by a large group of participants including equipment manufacturers, tubing manufacturers, chemical manufacturers, system designer/engineers, equipment manufacturer representatives, labor unions and installing contractors.

After requirements were established, the committee worked to develop schematics that align with the intent of the standard which focused on increasing life expectancy of these systems. As a result, two schematics were generated to address systems which use chemical additives, and one schematic was generated to address systems that do not use chemical additives. In systems where chemical additives are not used, the installation and location of air separation and air removal devices must coincide with areas within the hydronic systems where air is likely to accumulate.

Additionally, the criticality of the expansion tank’s connection and location in relationship to circulators, air separators, heat sources, and pressure relief valves cannot be overstated, and it is critical to correct for trouble free operation of hydronic systems. Where improperly configured, these systems suffer irreparable harm due to dilution of makeup water into a properly balanced system. The intent of these drawings is to provide specific guidance in system configuration for system designers and installers to help avoid these problems.

**COMMITTEE ACTION:** ACCEPT AS AMENDED BY THE TC
401.0 General.
401.1 Applicability. This chapter shall apply to hydronic piping systems that are part of heating, cooling, ventilation, refrigeration, and air conditioning systems. Such piping systems include steam, hot water, radiant heating and cooling, chilled water, steam condensate, condenser water, solar thermal systems, ground source heat pump systems, snow and ice melt systems, ambient temperature loops (ATL), and district thermal energy loops. The regulations of this chapter shall govern the construction, location, and installation of hydronic piping systems. (See Appendix E for recommended configurations of both residential and non-residential closed-loop hydronic heating and cooling systems.)

APPENDIX E
RECOMMENDED CONFIGURATIONS FOR MAINTAINING QUALITY OF HEAT TRANSFER FLUIDS IN CLOSED-LOOP HYDRONIC SYSTEMS

E 101.0 General.
E 101.1 Applicability. This appendix provides recommended configurations for both residential and non-residential closed-loop hydronic heating and cooling systems.
E 101.2 Purpose. The recommended configurations serve as a means of maintaining quality of heat transfer fluids over the life of the system and optimizing the life of system components.

E 102.0 Near Boiler Piping Schematics.
E 102.1 Systems with Chemical Additives. See Figure E 102.1(1) for a recommended near boiler piping schematic of a closed-loop hydronic system with chemical additives. The air separator is located at the optimal point within the system. See Figure E 102.1(2) for a recommended near boiler piping schematic of a closed-loop hydronic system utilizing glycol as the heat transfer fluid.

FIGURE E 102.1(1)
NEAR BOILER PIPING SCHEMATIC – CHEMICAL ADDITIVES
Note: This configuration is not applicable to hydronic systems containing antifreeze on the load side of the system. [e.g. snow and ice melt systems (SIMS)]
E 102.2 Systems without Chemical Additives. See Figure E 102.2 for a recommended configuration for a closed-loop hydronic system without chemical additives. The air separator is located at the optimal point within the system.
COMMITTEE STATEMENT:
Item #021 Public Comment 02 is being modified to carry over the accepted changes from Item #021 Public Comment 01 which removed "ambient temperature loops" from Section 401.1 (Applicability). Additionally, the title of the new appendix is being updated to better align with both the source document IAPMO/ANSI H1001.1 (Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems) and the purpose of the recommended configurations.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 11 NEGATIVE: 5

EXPLANATION OF NEGATIVE:

CHRISMAN: I agree with Jeff Matson's comment.

HALDIMAN: I agree with Jeff Matson's comment.

MACK: I agree with Jeff Matson's comment.

MATSON: I think that rather than having an appendix with diagrams, the Code should simply refer to IAPMO/ANSI H1001.1 for those, and that this crosses from health and safety requirements into best practice.

MURRAY: I agree with Jeff Matson regarding this.
Item #: 022
USHGC 2024 Section: 401.3, 401.9

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

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.

401.9 Flexible Connectors. Listed flexible connectors shall be installed in readily accessible locations, unless otherwise-listed.

SUBSTANTIATION:
Section 401.3 is being revised since the piping system must be sized to accommodate the flow of hydronic fluid rather than the flow be designed to prevent a water hammer. The current language is oddly worded and may cause confusion. Such modifications are necessary for clarification. Furthermore, Section 401.9 is being revised to remove “unless otherwise listed” as this phrase permits the installation of connectors in non-accessible locations. Also, the section already specifies that the flexible connectors are listed.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:

AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC Section #: 225.0

SUBMITTER: Monte Myers
Self

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

225.0 – W –
Water Hammer. A hydraulic shock that occurs within a pressurized piping system resulting from a pressure surge propagating through the piping system when fluid flow abruptly changes direction. Such shockwaves may occur in any piping system where valves are used to control the flow of liquids or steam, when the fluid flow within the system is suddenly stopped and the fluid momentum is broken.
SUBSTANTIATION:
The existing definition is incorrect regarding "fluid flow within the system is suddenly stopped." Water hammer refers to the sudden change in velocity or direction of the system fluids, but the flow or momentum does not suddenly stop. The resulting shockwaves are essentially caused by this transient pressure phenomenon.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

225.0 – W –
Water Hammer. A hydraulic shock that occurs within a pressurized piping system resulting from a pressure surge propagating through the piping system when fluid flow abruptly changes velocity or direction. Such shockwaves may occur in any piping system where valves are used to control the flow of liquids or steam.

COMMITTEE STATEMENT:
In Item #022 Public Comment 01, the definition for “water hammer” is being modified to clarify that the hydraulic shock occurs when the fluid flow changes “velocity or direction.” Additionally, the language stating “such shockwaves may occur in any piping system where valves are used to control the flow of liquids or steam” is being removed. This statement is not required when interpreting the definition, and the terminology provided should only align with systems addressed within the USHGC rather than “any piping system.”

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 025
USHGC 2024  Section: 401.7

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Add new text

401.0 General.

401.7 Disposal of Hydronic Fluid. Hydronic system fluids that contain additives such as antifreeze, corrosion inhibitors, and cleaning solutions shall be recycled or disposed of in an approved manner in accordance with the Authority Having Jurisdiction.

(renumber remaining sections)

SUBSTANTIATION:
Currently, the code is silent on the disposal of used hydronic fluids. The proposed section offers provisional language which ensures proper disposal of such fluids and promotes public health and safety. In some cases, the used hydronic fluid may be recycled. For these reasons, the new language is necessary and beneficial to the USHGC.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 401.7

SUBMITTER: Arnold Rodio
Chair, USHGC-USPSHTC Technical Correlating Committee

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

401.0 General.

401.7 Disposal of Hydronic Fluid Disposal. Hydronic system fluids that contain additives such as antifreeze, corrosion inhibitors, and cleaning solutions shall be recycled or disposed of in an approved manner in accordance with the Environmental Protection Agency (EPA), the Department of Health, and as required by the Authority Having Jurisdiction.
SUBSTANTIATION:
The USHGC-USPSHTC TCC has generated a recommendation for USHGC Item # 025, Section 401.7 (Disposal of Hydronic Fluid) to be submitted as a USHGC Public Comment for consideration at the next USHGC TC meeting. The recommendation includes a revision to the title of the section as well as required compliance with the Environmental Protection Agency (EPA), the Department of Health, and the Authority Having Jurisdiction when disposing of hydronic system fluids containing additives such as antifreeze, corrosion inhibitors, and cleaning solutions. The USHGC-USPSHTC TCC recommendation correlates with the action taken by the UMC TC to “accept as amended” Item #239.01 Comment 1 as published in the 2022 UMC Report on Comments.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #025 Public Comment 01 is being rejected as the committee does not agree with identifying or referencing certain governing bodies. Both the Environmental Protection Agency (EPA) and the Department of Health are covered under the umbrella term “Authority Having Jurisdiction” as defined in Chapter 2 of the USHGC, and therefore, listing different governing bodies is unnecessary.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 026
USHGC 2024 Section: 401.10, Table 401.10

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

401.0 General.

401.10 Freeze Protection. Hydronic systems and components shall be designed, installed, and protected from freezing. The percent of glycol by volume shall be determined based on the freezing point of the solution and type of mixture in accordance with Table 401.10, or the manufacturer’s specifications.

<table>
<thead>
<tr>
<th>PERCENT GLYCOL BY VOLUME (% v/v)</th>
<th>FREEZING POINT, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETHYLENE GLYCOL*</td>
<td>PROPYLENE GLYCOL</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>-12</td>
</tr>
<tr>
<td>50</td>
<td>-35</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8

*Ethylene glycol shall not be used in one- and two-unit residential systems. Where ethylene glycol is used, there shall be no potable water connections.

SUBSTANTIATION:
In systems where glycol is an additive, bacteria can be controlled by maintaining a percent glycol by volume of at least 20. This percentage may vary based on manufacturer’s specifications; however, both propylene and ethylene glycol have been proven to inhibit the growth of most microbes at concentrations of 20 percent or more.

Proposed Table 401.10 is an excerpt from IAPMO/ANSI H1001.1 and is beneficial to include in this chapter as it provides a method for determining the required percent glycol by volume given the freezing point of the solution. Due to the toxicity of ethylene glycol, restrictions for its use have been put in place. Ethylene glycol ingestion can be lethal to humans and wildlife while propylene glycol is essentially nontoxic in small quantities.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

401.0 General.

401.10 Freeze Protection. Hydronic systems and components shall be designed, installed, and protected from freezing. The percent of glycol by volume shall be determined based on the freezing point of the solution and type of mixture in accordance with Table 401.10, or the manufacturer’s specifications.
TABLE 401.10
PERCENT GLYCOL MIXTURES

<table>
<thead>
<tr>
<th>PERCENT GLYCOL BY VOLUME (% v/v)</th>
<th>FREEZING POINT, °F</th>
<th>ETHYLENE GLYCOL*</th>
<th>PROPYLENE GLYCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>16</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>-12</td>
<td>-7</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>-35</td>
<td>-28</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8

*Ethylene glycol shall not be used in one- and two-unit residential systems. In existing systems where ethylene glycol is used, there shall be no direct or permanent potable water connections. Where a temporary potable water connection is required, a backflow preventer shall be installed.

COMMITTEE STATEMENT:
The proposal is being modified to prevent conflict with the accepted language from Item #023 for ethylene glycol regarding backflow prevention and the protection of potable water connections. Such revisions are also consistent with the recent action taken by the UMC Technical Committee for Item #239.02 Public Comment 3.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 13 NEGATIVE: 3

EXPLANATION OF NEGATIVE:
CHRISMAN: I agree with Cody Mack.

KEMPER: Further clarification should be provided on the type of cross connection control device utilized in accordance with the UPC.

MACK: Provisions for freeze protection are necessary but antifreeze is not the only solution. It is currently common practice in monobloc air source heat pump applications throughout the world to continue using water as the heat transfer fluid despite the piping being installed outdoors. To prevent damage from freezing conditions, antifreeze valves are installed in the exposed piping to drain the heat transfer fluid from the system below a certain temperature. This allows for protection from freezing while avoiding heat transfer penalties through the use of glycol. Antifreeze valves are currently recommended and/or provided by many manufacturers. I will bring this up in public comment.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC Section #: 401.11
Item #: 026

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

401.0 General.

401.11 Freeze Protection. Hydronic systems and components shall be designed, installed, and protected from freezing. Where glycol is used for freeze protection, the percent of glycol by volume shall be determined based on the freezing point of the solution and type of mixture in accordance with Table 401.11, or the manufacturer’s specifications.
<table>
<thead>
<tr>
<th>PERCENT GLYCOL BY VOLUME (% v/v)</th>
<th>FREEZING POINT, °F</th>
<th>ETHYLENE GLYCOL*</th>
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<td>-7</td>
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<tr>
<td>50</td>
<td>-35</td>
<td>-28</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8

*Ethylene glycol shall not be used in one- and two-unit residential systems. In existing systems where ethylene glycol is used, there shall be no direct or permanent potable water connections. Where a temporary potable water connection is required, a backflow preventer shall be installed.

SUBSTANTIATION:
The minor revision to Section 401.11 (Freeze Protection) is being proposed as it prevents overly restrictive language pertaining to glycol used in hydronic systems for freeze protection. Since there are hydronic systems which use non-chemical methods of freeze protection, there must be language which states that these provisions only apply where glycol is utilized. In summary, the additional language is necessary as it clarifies that “where glycol is used” as a means of freeze protection, the percent glycol by volume must comply with Table 401.11 (Percent Glycol Mixtures).

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 027

USHGC 2024  Section: 401.10.1

SUBMITTER: Jeff Matson
   Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Add new text

401.0 General.

401.10 Freeze Protection. (remaining text unchanged)
401.10.1 Antifreeze Requirements. Antifreeze shall be added to a closed hydronic system where one or more of the following conditions are met:
(1) System component(s) are exposed to freezing conditions during normal operation,
(2) The hydronic system serves as a snow and ice melt system in accordance with Section 417.0, or
(3) Where required by the equipment manufacturer.

SUBSTANTIATION:
The new language is necessary as it increases freeze protection for hydronic systems. The current language for freeze protection does not give specific requirements for when freeze protection should be provided. The above listed conditions are clear and also assist with maintaining heat transfer fluid quality and improving longevity of these systems.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 14  NEGATIVE: 2

EXPLANATION OF NEGATIVE:
CHRISMAN: Would be overly restrictive.

MACK: Provisions for freeze protection are necessary but antifreeze is not the only solution. It is currently common practice in monobloc air source heat pump applications throughout the world to continue using water as the heat transfer fluid despite the piping being installed outdoors. To prevent damage from freezing conditions, antifreeze valves are installed in the exposed piping to drain the heat transfer fluid from the system below a certain temperature. This allows for protection from freezing while avoiding heat transfer penalties through the use of glycol. Antifreeze valves are currently recommended and / or provided by many manufacturers. I will bring this up in public comment.

Appended Comments
PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 401.11.1  Item #: 027
SUBMITTER: Jeff Matson  Chair, USHGC Hydronics Systems Task Group
Comment #: 1

RECOMMENDATION: Accept as Modified

Request to accept the code change proposal as modified by this public comment.

401.0 General.

401.11 Freeze Protection. (remaining text unchanged)
401.11.1 Antifreeze Requirements. Antifreeze shall be added to a closed hydronic system where one or more of the following conditions are met: (1) System component(s) are exposed to freezing conditions during normal operation, (2) The hydronic system serves as a snow and ice melt system in accordance with Section 417.0, or (3) Where required by the equipment manufacturer.

Exception: Antifreeze shall not be required where a system is continuously monitored or specifically designed not to require antifreeze, and is not subject to freezing as a result of either of the following: (1) Loss of electrical power, (2) Loss of a fuel source.

SUBSTANTIATION:
Section 401.11.1 (Antifreeze Requirements) is being updated to include minor revisions as well as new exceptions for these requirements. The phrase “during normal operation” is vague and excludes systems which are dormant but still may contain hydronic system fluids within the piping system. In such circumstances, there exists the possibility of pipe bursts or leaks resulting from freezing conditions. In order to protect these systems under varying circumstances, this phrasing should be removed.

The exceptions have been added to prevent overly restrictive provisions pertaining to antifreeze requirements as there are systems which may be “continuously monitored or specifically designed not to require antifreeze.” These exceptions correlate with IAPMO/ANSI H1001.1 (Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems), which was previously accepted for reference in Section 401.6 (Heat Transfer Fluid Quality). For both consistency between requirements and the inclusion of allowable exceptions, the revisions are necessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 029
USHGC 2024  Section: 403.2

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

403.0 Capacity of Heat Source.

403.2 Dual Purpose Water Heaters. Water heaters utilized for combined space-heating and water-heating applications shall be listed and 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.

SUBSTANTIATION:
The revisions to Section 403.2 (Dual Purpose Water Heaters) clarify requirements for dual purpose water heaters. Rather than requiring listing and labeling of these heaters, compliance with the applicable standards referenced in Table 403.2 (Water Heaters) is sufficient. For these reasons, the above modifications are necessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 206.0

SUBMITTER: Jim Majerowicz
Plumbers Local Union 130 U.A.

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

206.0  - D -
Dual Purpose Water Heater. An appliance intended to be a heat source for both space heating and domestic hot water applications.
SUBSTANTIATION:
The proposed change to the definition of “dual purpose water heater” includes replacing the phrase "utilized as" with "intended to be." The use of this phrasing may have been an oversight as these appliances have the sole purpose of being a heat source for both space heating and cooling applications. This language also correlates with both the Uniform Mechanical Code and the Uniform Plumbing Code.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 030

USHGC 2024  Section: 403.4

SUBMITTER: Lance MacNevin
Plastics Pipe Institute

RECOMMENDATION:
Add new text

403.0 Capacity of Heat Source.

403.4 Potable Water as a Hydronic Fluid. Potable water shall not be used as a hydronic fluid in an open-loop heating system unless all of the following conditions are met:

(1) A maximum of one system loop using potable water as the hydronic fluid is allowed per heat source;
(2) The total length of piping of the heating system containing potable water does not exceed 50 feet (15 240 mm);
(3) The total volume of potable water in the heating system loop, including the volume within the heat-distribution unit(s), heat exchanger, or radiant surface, does not exceed 13 gallons (49 L); and
(4) The normal operating supply temperature of the potable water to the heat-distribution unit(s), heat exchanger, or radiant surface is not less than 140°F (60°C).

SUBSTANTIATION:
This proposal will improve the safety of plumbing systems and promote public health by restricting the use of combined (also known as cross-connected) potable-hydronic systems, where hydronic water is mixed with potable water by being returned into the water heater after circulating through hydronic distribution devices and piping. These systems create the risk of stagnant water from the hydronic distribution network being returned into the potable water system.

Combined potable-hydronic systems are currently allowed by the code without any restriction on the volume of water or piping in the hydronic distribution portion. These new restrictions which are proposed for Section 403.4 were recently added to the 2021 edition of CSA B214 (Installation Code for Hydronic Heating Systems) in Clause 4.2.5.1.

The proposed restriction limits combined systems to only smaller hydronic systems with a minimal amount of water to reduce the volume of piping and water in which biofilm or bacteria such as Legionella could grow. For example, a radiant heating system with 1,000 feet of tubing receiving its heated water from a potable water heater would not be allowed with this new language. On the other hand, a fan coil that is installed nearby the water heater would still be allowed, as long as the specific limits in the new sections are not exceeded.

Background: Research indicates that bacterium Legionella pneumophila can grow in water between 68°F and 120°F (20°C to 48°C), with an ideal growth range of 85°F to 110°F (29°C to 43°C).

In a typical residential plumbing system, with 200 to 300 feet of hot-water piping, disinfectants in treated water can control the growth of Legionella. Hot water is normally delivered to outlets quickly, and the age of the water is not a concern. Even though drinking water disinfectants can dissipate quickly after being exposed to the heat of a water heater, some level of disinfectant normally remains until water is delivered to a fixture.
However, if the plumbing system is connected to a hydronic distribution system, such as a radiant heating system, this can lead to a large volume of water which is stagnant at times. For example, when the heating system turns off, there could be a significant volume of warm stagnant water sitting in pipes, fan coils, radiators, and other hydronic components.

Over time, this water could contain little to no disinfectant while being maintained at the ideal temperature range for Legionella growth. When the heating system turns on due to a call for heat, that stagnant water will re-enter the water heater and then travel through the plumbing distribution system to the next fixture that is opened. Water becomes aerosolized (i.e., droplets and vapor) in a shower or near an aerated faucet and is easy to inhale. This is a potentially dangerous situation for people who are susceptible to this type of bacteria, as this can allow Legionella to enter the lungs.

During periods of inactivity (e.g., summer), the water in heating components might be stagnant for weeks or months. Although the water is at or near ambient room temperature, and Legionella will grow more slowly, it does not die. Further, stagnant water has been shown to allow the growth of biofilms inside piping components and appurtenances.

Therefore, this proposal will significantly reduce the potential volume of water in combined (cross-connected) potable-hydraulic systems and improve public health and safety.

The potential risks of combined (cross-connected) potable-hydraulic systems are described in PPI's "Recommendation Against Mixing Hydronic Heating Water with Potable Water in Combined Systems" https://plasticpipe.org/common/Uploaded%20files/1-PPI/RECOMMENDATIONS/Recommendation%20E.pdf

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 402.1, 402.3 - 402.5, 403.4

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

402.0 Protection of Potable Water Supply.

402.1 Prohibited Sources-Connections. Hydronic systems or parts thereof, shall be constructed in such a manner that polluted, contaminated water, or substances shall not enter hydronic system fluid does not enter a portion of the potable water distribution system or from being separately delivered to any potable water fixture or point of use 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.

402.3 Protection of Potable Water. Where a hydronic system makeup fluid supply is connected to a potable water system, the potable water system shall be protected from backflow from the hydronic system in accordance with the Uniform Plumbing Code.
402.4 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.

402.5 Dual Purpose Water Heaters. Dual purpose water heaters shall be configured to maintain fluid separation between the potable water and the hydronic system fluid. Where an integral heat exchanger is installed in a dual purpose water heater, the installation shall comply with the requirements for a single-wall heat exchanger in Section 313.1. Scald protection shall be provided on the potable water circuit in compliance with ASSE 1070/ASME A112.1070/CSA B125.70, point of generation requirements.

403.0 Capacity of Heat Source.

403.4 Potable Water as a Hydronic Fluid. Potable water shall not be used as a hydronic fluid in an open-loop heating system unless all of the following conditions are met:

(1) A maximum of one system loop using potable water as the hydronic fluid is allowed per heat source;
(2) The total length of piping of the heating system containing potable water does not exceed 50 feet (15 240 mm);
(3) The total volume of potable water in the heating system loop, including the volume within the heat-distribution unit(s), heat exchanger, or radiant surface, does not exceed 13 gallons (49 L); and
(4) The normal operating supply temperature of the potable water to the heat-distribution unit(s), heat exchanger, or radiant surface is not less than 140°F (60°C).

<table>
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</table>

(portion of table not shown remains unchanged)

Note: ASSE 1070/ASME A112.1070/CSA B125.70 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.

(below shown for information purposes only)

313.0 Heat Exchangers.

313.1 General. Systems utilizing heat exchangers shall protect the potable water system from being contaminated by the heat transfer medium. Systems that incorporate a single-wall heat exchanger to separate potable water from the heat-transfer fluid shall meet the following requirements:

(1) Heat transfer medium is either potable water or contains fluids recognized as safe by the Food and Drug Administration (FDA) as food grade.
(2) A tag or label shall be securely affixed to the heat source with the word “CAUTION” and the following statements:
   (a) The heat transfer medium shall be water or other nontoxic fluid recognized as safe by the FDA.
   (b) The maximum operating pressure of the heat exchanger shall not exceed the maximum operating pressure of the potable water supply.
(3) The word “CAUTION” and the statements listed above shall have an uppercase height of not less than 0.120 of an inch (3.05 mm). The vertical spacing between lines of type shall be not less than 0.046 of an inch (1.168 mm). Lowercase letters shall be not less than compatible with the uppercase letter size specification.

   Systems that do not comply with the requirements for a single-wall heat exchanger shall install a double-wall heat exchanger. Double-wall heat exchangers shall separate the potable water from the heat transfer medium by providing a space between the two walls that are vented to the atmosphere.

SUBSTANTIATION:
During their discussion and review, the Task Group determined that comingling of hydronic system fluid and potable water is too great of a health risk to be allowed by any codes, whose primary purpose is that of public health and safety. Furthermore, once a system has a final inspection, the code and the Authority Having Jurisdiction no longer have any control over how it is used or maintained. When operation is contingent on the function of disparate components, as opposed to being affected entirely by a listed appliance, there is simply no possibility of legislating the health and safety issues over the lifetime of the installation. Because this practice is not specifically prohibited by other codes, it is necessary to address this directly in the USHGC.
Section 402.1 (Prohibited Connections) is best stated as a prohibition against connections, i.e., comingling. This is to bolster the prohibition against comingling, by specifically addressing what happens after passing the mandatory backflow preventer.

Resulting from this determination, the Task Group also revised Section 402.3 (Protection of Potable Water) and Section 402.4 (Compatibility) and proposed new Section 402.5 (Dual Purpose Water Heaters). Requirements for protection of the potable water supply are still bound by the plumbing code, however additional language has been provided to specify that the potable water system is to be protected from backflow from the hydronic system. This language is clearer and more appropriately aligns with the provisions of the chapter.

Section 402.5 (Dual Purpose Water Heaters) includes the removed language from Section 402.4 (Compatibility) pertaining to single wall heat exchangers in compliance with Section 313.1 (Heat Exchangers – General), and the use of the phrase “integral heat exchanger” covers dual circuit tankless water heaters permitted under these provisions. Additionally, provisions have been included requiring dual purpose water heaters to maintain fluid separation between the potable water and hydronic system fluid. In efforts to offer additional safety, scald protection requirements have also been proposed. ASSE 1070/ASME A112.1070/CSA B125.70 specifically addresses performance requirements for water temperature limiting devices intended to limit the hot or tempered water temperature supplied to fixtures to reduce the risk of scalding.

Since the Task Group intends to prohibit comingling of system fluids, Section 403.4 (Potable Water as a Hydronic Fluid) is being deleted in its entirety.

The Task Group’s public comment submitted on Item #048 further supports this prohibition of comingled system fluids and proposes the necessary revisions to Section 412.4 (Automatic Makeup Fluid).

**COMMITTEE ACTION: ACCEPT AS SUBMITTED**

**TOTAL ELIGIBLE TO VOTE: 16**

**VOTING RESULTS: AFFIRMATIVE: 16**
Proposals

Item #: 032
USHGC 2024 Section: 404.7

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

404.0 Identification of Piping Systems.

404.7 Heat Transfer Fluid. Solar thermal-Hydronic piping shall be identified with an orange background with black uppercase lettering, with the words “CAUTION: HEAT TRANSFER FLUID, DO NOT DRINK.” Each solar thermal-hydronic system shall be identified to designate the fluid being conveyed. The minimum size of the letters and length of the color field shall comply with Table 404.3.

Each outlet on the solar thermal-hydronic piping system shall be posted with black uppercase lettering as follows: “CAUTION: HEAT TRANSFER FLUID, DO NOT DRINK.”

SUBSTANTIATION:
Section 404.7 is being updated to reference “hydronic” piping and system components rather than “solar thermal” since this chapter is explicit to hydronics systems. Solar thermal provisions belong in Chapter 5 (Solar Thermal Systems).

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

404.0 Identification of Piping Systems.

501.0 General.

501.18 Heat Transfer Fluid. Solar thermal Hydronic piping shall be identified with an orange background with black uppercase lettering, with the words “CAUTION: HEAT TRANSFER FLUID, DO NOT DRINK.” Each solar thermal-hydronic system shall be identified to designate the fluid being conveyed. The minimum size of the letters and length of the color field shall comply with Table 404.3.

Each outlet on the solar thermal-hydronic piping system shall be posted with black uppercase lettering as follows: “CAUTION: HEAT TRANSFER FLUID, DO NOT DRINK.”

COMMITTEE STATEMENT:
The Technical Committee believes that the heat transfer fluid provisions apply to solar thermal rather than hydronic systems. For this reason, the original language is being kept, and the section is being relocated to Chapter 5 (Solar Thermal Systems).

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 404.0 - 404.3  
SUBMITTER: Jazmin Curiel  Self  
Item #: 032  Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

404.0 Identification of Piping Potable and Nonpotable Water Systems.

404.1 General. In buildings where potable water and nonpotable water systems are installed, each system shall be clearly identified in accordance with Section 404.2 through Section 404.5.

404.2 Color and Information. Each system shall be identified with a colored pipe or band and coded with paints, wraps, and materials compatible with the piping.

404.3 Potable Water. Potable water systems shall be identified with a green background with white lettering. The minimum size of the letters and length of the color field shall be in accordance with Table 404.3.

SUBSTANTIATION:
The title of Section 404.0 is being modified to “Identification of Potable and Nonpotable Water Systems” as the section applies to both. The current title is not indicative of the provisions laid out in the section and should therefore be revised. Other minor revisions are also required to correct grammar.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

404.0 Identification of Piping Potable and Nonpotable Water Piping Systems.

404.1 General. In buildings where potable water and nonpotable water systems are installed, each system shall be clearly identified in accordance with Section 404.2 through Section 404.5.

404.2 Color and Information. Each system shall be identified with a colored pipe or band and coded with paint, wraps, and materials compatible with the piping.

404.3 Potable Water. Potable water systems shall be identified with a green background with white lettering. The minimum size of the letters and length of the color field shall be in accordance with Table 404.3.

COMMITTEE STATEMENT:
In Item #032 Public Comment 01, the title of Section 404.0 is being modified from “Identification of Potable and Nonpotable Water Systems” to “Identification of Potable and Nonpotable Water Piping Systems.” This amended title clarifies that the provisions under this section pertain to identification of “piping.” Without this distinction, the end user may misinterpret the language as requiring labeling of every component.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 035
USHGC 2024 Section: 408.1

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

408.0 Expansion Tanks.
408.1 General. An expansion tank shall be installed in each closed-loop of a hydronic system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed type, incorporating a diaphragm or bladder to ensure the isolation of the system fluid from the pre-charge gas or from the atmosphere. Plain compression tanks shall not be permitted. Expansion tanks shall be rated for the pressure of the system.

Exceptions:
(1) Drainback type solar thermal systems shall not require a hydronic expansion tank.
(2) An alternative engineered fluid expansion storage system shall be permitted where in accordance with Section 302.4.

(Section 302.4 is shown for information purposes only)

302.4 Alternative Engineered Design. An alternative engineered design shall comply with the intent of the provisions of this code and shall provide an equivalent level of quality, strength, effectiveness, fire resistance, durability, and safety. Material, equipment, or components shall be designed and installed in accordance with the manufacturer’s installation instructions.

SUBSTANTIATION:
Requiring a bladder or diaphragm is automatically inclusive of active expansion systems. This requirement does not need to specify how fluid is moved in or out of the loop, nor how the charge pressure is or is not modulated. The intent of the proposed language is to eliminate exposure to the atmosphere. For these reasons, the modifications to Section 408.1 are necessary.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

408.0 Expansion Tanks.
408.1 General. An expansion tank shall be installed in each hydronic closed-loop of a hydronic system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed type, incorporating a diaphragm or bladder to ensure the isolation of the system fluid from the pre-charge gas or from the atmosphere. Plain compression tanks shall not be permitted. Expansion tanks shall be rated for the pressure of the system.

Exceptions:
(1) Drainback type solar thermal systems shall not require a hydronic expansion tank.
(2) An alternative engineered fluid expansion storage system shall be permitted where in accordance with Section 302.4. to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion.
 COMMITTEE STATEMENT:
The proposal is being modified to clarify that expansion tanks are required for each "hydronic closed-loop system." The language as proposed was confusing and would possibly lead to misinterpretation.

Additionally, exception (2) is being updated to include portions of exception (1) from Item #036. The Technical Committee agreed that such language was beneficial as there are engineered fluid expansion storage systems which use vessels open to the atmosphere.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Public Comment 1

Code Year: 2024 USHGC Section #: 408.1, Figure 408.1(1), Figure 408.1(2) Item #: 035
Submitter: Lee Stevens LH Stevens Construction LLC Comment #: 1

Recommendation:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

408.0 Expansion Tanks.

408.1 General. An expansion tank shall be installed in each hydronic closed-loop system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed type, incorporating a diaphragm or bladder to ensure the isolation of the system fluid from the pre-charge gas or from the atmosphere. Plain compression tanks shall not be permitted. Expansion tanks shall be rated for the pressure of the system. [See Figure 408.1(1) for a simplified schematic of a closed-loop system incorporating a diaphragm type expansion tank.]

Exceptions:
(1) Drainback type solar thermal systems shall not require a hydronic expansion tank.
(2) An engineered fluid expansion storage system shall be permitted to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]
FIGURE 408.1(1)\textsuperscript{1,2}
CLOSED-LOOP SYSTEM WITH DIAPHRAGM TYPE EXPANSION TANK
(SIMPLIFIED SCHEMATIC)

Notes:
\textsuperscript{1} This schematic does not include all system components, and configurations may vary based on design.
\textsuperscript{2} A makeup supply may be provided using any type of fluid source. The makeup supply is not considered part of the closed-loop.
ENGINEERED FLUID EXPANSION STORAGE SYSTEM (ATMOSHERIC) (SIMPLIFIED SCHEMATIC)

Notes:
1. This schematic does not include all system components, and configurations may vary based on design.
2. The atmospheric expansion tank accommodates thermal expansion and contraction of the system fluid.

SUBSTANTIATION:
The inclusion of the submitted figures will serve to clarify what is and is not a constituent part of a closed-loop system. This is particularly important regarding the distinction between air venting and atmospheric exposure and aids in the enforcement of IAPMO/ANSI H1001.1 (Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems).

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

408.0 Expansion Tanks.
408.1 General. An expansion tank shall be installed in each hydronic closed-loop system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed type, incorporating a diaphragm or bladder to ensure the isolation of the system fluid from the pre-charge gas or from the atmosphere. Plain compression tanks shall not be permitted. Expansion tanks shall be rated for the pressure of the system. [See Figure 408.1(1) for an example of a simplified schematic of a closed-loop system incorporating a diaphragm type expansion tank.]

Exceptions:
(1) Drainback type solar thermal systems shall not require a hydronic expansion tank.
(2) An engineered fluid expansion storage system shall be permitted to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]
FIGURE 408.1(1)^1,2
EXAMPLE OF A CLOSED-LOOP SYSTEM WITH DIAPHRAGM TYPE EXPANSION TANK
(SIMPLIFIED SCHEMATIC)

Notes:
^1 This schematic does not include all system components, and configurations may vary based on design.
^2 A makeup supply may be provided using any type of fluid source. The makeup supply is not considered part of the closed-loop.
FIGURE 408.1(2)¹,²
EXAMPLE OF AN ENGINEERED FLUID EXPANSION STORAGE SYSTEM (ATMOSPHERIC)
(SIMPLIFIED SCHEMATIC)

Notes:
¹ This schematic does not include all system components, and configurations may vary based on design.
² The atmospheric expansion tank accommodates thermal expansion and, or contraction of the system fluid.

COMMITTEE STATEMENT:
Item #035 Public Comment 01 is being amended to clarify that both Figure 408.1(1) and Figure 408.1(2) are "examples" of simplified schematics. The reference to Figure 408.1(2) in Exception (2) already reflects this distinction. Therefore, the same phrasing was used for Figure 408.1(2) in Exception (2) already reflects this distinction. Therefore, the same phrasing was used for Figure 408.1(1) in Section 408.1. For consistency and clarity, the titles of both Figure 408.1(1) and Figure 408.1(2) were also amended.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 037
USHGC 2024  Section: 408.2, 605.1

SUBMITTER: Jeff Matson  
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

408.0 Expansion Tanks.

408.2 Installation. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions. Each expansion tank shall be equipped with a shutoff device that will remain open during operation of the hydronic system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off. Where systems contain more than 5 gallons (19 L) of fluid, provisions shall be made for draining the tank without emptying the system. Expansion tanks shall be securely fastened to the structure. Supports shall be capable of carrying twice the weight of the tank filled with water without placing a strain on connecting piping. Hot-water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

605.0 Expansion Tanks.

605.1 Where Required. An expansion tank shall be installed in a water heating system as a means for controlling increased pressure caused by thermal expansion. Expansion tanks shall be of the closed type and securely fastened to the structure. Tanks shall be rated for the pressure of the system. Supports shall be capable of carrying twice the weight of the tank filled with water without placing strain on the connecting piping. Water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

SUBSTANTIATION:
The current language only requires systems larger than 5 gallons to have a means of draining the tank without emptying the system. Removing the provided minimum volume makes this requirement applicable to systems of all sizes.

Additionally, the revision made to update the language to show "securely fastened to or supported by the structure" provides further clarification for the installation of expansion tanks and correlates with the other recommendations provided by this Task Group. This modification also makes the provisions less restrictive and more practical.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16
PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 605.1
SUBMITTER: Lee Stevens  LH Stevens Construction LLC

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

605.0 Expansion Tanks.
605.1 Where Required. An expansion tank shall be installed in a water heating system as a means for controlling increased pressure caused by thermal expansion. Expansion tanks shall be of the closed type and securely fastened to or supported by the structure. Tanks shall be rated for the pressure of the system. Supports shall be capable of carrying twice the weight of the tank filled with water without placing strain on the connecting piping. Water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

Exception: An engineered fluid expansion storage system shall be permitted to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]

SUBSTANTIATION:
Section 605.1 (Where Required) is essentially the same language and provisions as Section 408.1 (Expansion Tanks - General). Therefore, the exception for engineered alternatives should also be inserted here to avoid contradictory regulations. (See Item #035 Public Comment 1).

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2

Code Year: 2024 USHGC  Section #: 605.1, 605.2
SUBMITTER: Monte Myers  Self

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

605.0 Expansion Tanks.
605.1 Where Required. An expansion tank shall be installed in a water heating system as a means for controlling increased pressure caused by thermal expansion. Expansion tanks shall be of the closed type or open type and shall be securely fastened to or supported by the structure. Tanks shall be rated for the pressure of the system. Supports shall be capable of carrying twice the weight of the tank filled with water without placing strain on the connecting piping. Water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

605.2 Systems with 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. Such tanks shall be sized based on the capacity of the system. An overflow with a diameter of not less than one-half the size of the water 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.

(renumber remaining sections)
SUBSTANTIATION:
Expansion tanks are either sealed vessels or open tank reservoirs. Open tank reservoirs are, of course, not pressurized except for the static elevation head they impose on the equipment served. The current language prohibits the use of open-type expansion tanks. However there are applications in which such tanks should be allowed. The use of open-type expansion tanks can be beneficial in that their operation does not depend on the performance of the system. The simplicity of their design is also a benefit.

As stated by April Trafton in the 2011 USHGC Report on Comments, “Open-type expansion tanks are nothing more than elevated reservoirs holding the expanded hot water at atmospheric pressure. An adequately sized open-type tank would have the capacity to hold, without overflowing and admitting air into the system, the maximum volume of water that would expand from the system at the maximum operating temperature. Because this type of expansion tank is open to the atmosphere, it must be located at an elevation above the highest system components and OSHA recommends 3 feet as this will produce a slight head pressure which assists in the purging of air.

Open-type expansion tanks are utilized in heating and/or chilled water-cooling systems as a buffer for the thermal expansion and contraction of the heated or cooled water. Open-type expansion tanks must be located at the highest point of each circulating zone to maintain a flooded system. Special controls are used to maintain the proper water level within the tank. In addition, the design of open expansion tanks shall include an overflow and vent from the upper portion of the tank.”

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #037 Public Comment 02 is being rejected as the proposed requirements for “systems with open type expansion tanks” are too specific and overly restrictive. Additionally, the essential requirements are already addressed in other sections of the USHGC. For these reasons, the committee does not agree with the proposed language.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 038
USHGC 2024  Section: 408.4

SUBMITTER: Jeff Matson  
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION: 
Revise text

408.0 Expansion Tanks.

408.4 Sizing. Expansion tanks shall be sized to accept the design 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 605.3.

SUBSTANTIATION: 
The proposed revision is necessary as it provides clarification for technical accuracy.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT: 
The proposal is being rejected since the expansion tanks are part of an engineered system that is required to accept the "design expansion volume," not the "full expansion volume."

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS:  AFFIRMATIVE: 16
EXPLANATION OF AFFIRMATIVE:
MACNEVIN: A public comment should clarify that this section applies to the hydronic network and not the geo ground loop.
Request to replace the code change proposal by this public comment.

408.0 Expansion Tanks.

408.4 Sizing. Expansion tanks shall be sized to accept the design expansion volume of the fluid in the system. The minimum capacity of a closed-type expansion tank shall be sized in accordance with Section 605.3.

(below shown for information purposes only)

605.3 Minimum Capacity of Closed-Type Tanks. The minimum capacity for a gravity-type hot water system expansion tank shall be in accordance with Table 605.3(1). The minimum capacity for a forced-type hot water system expansion tank shall be in accordance with Table 605.3(2) or Equation 605.3(1). The minimum capacity for diaphragm tanks shall be in accordance with Table 605.3(2) or Equation 605.3(2).

Where:

\[ C_1 = 0.00041 \]

\[ C_2 = 0.0466 \]

\[ V_t = \text{Minimum volume of expansion tank, gallons (L)} \]

\[ V_s = \text{Volume of system, not including expansion tank, gallons (L)} \]

\[ t = \text{Average operating temperature, °F (°C)} \]

\[ P_a = \text{Atmospheric pressure, pounds per square inch (kPa)} \]

\[ P_f = \text{Fill pressure, pounds per square inch (kPa)} \]

\[ P_o = \text{Maximum operating pressure, pounds per square inch (kPa)} \]

For SI units: \( C_1 = 0.000738, C_2 = 0.03348, 1 \text{ gallon} = 3.785 \text{ L}, °C = (°F-32)/1.8, 1 \text{ pound per square inch} = 6.8947 \text{ kPa} \)

SUBSTANTIATION:
The minor revision to Section 408.4 (Sizing) is necessary as it provides needed clarity. As shown above, Section 605.3 (Minimum Capacity of Closed-Type Tanks) provides equations for determination of tank volumes. Since the language already states “the minimum capacity of closed-type expansion tanks” are to be in accordance with Section 605.3, the use of the term “sized” is repetitive and unnecessary.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #038 Public Comment 01 is being rejected as the proposed modification to remove the term “sized” offers no additional clarity to Section 408.4 (Sizing). The committee also noted that this same change was submitted in the original proposal, and the action taken on Public Comment 01 further supports their previous rejection of Item #038.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Item #: 040
USHGC 2024  Section: 409.4

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

409.0 Materials.

409.4 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 foot 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:
The current provisions are not enforceable since oxygen barrier tubing is not marked with an exact permeation rate. The oxygen permeation value belongs in the product standard rather than the code. For these reasons, the proposed modification is necessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 409.4 - 409.4.2

SUBMITTER: Lee Stevens
LH Stevens Constructors LLC

RECOMMENDATION:
Accept as Submitted

Request to accept the code change proposal as modified by this public comment.

409.0 Materials.

409.4 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.

409.4.1 Vented Atmospheric Closed-Loop Systems. All components installed in a vented closed-loop system shall be constructed of non-ferrous or other corrosion resistant materials. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]
409.4.2 Non-Oxygen Barrier Closed-Loop Systems. All components installed in a non-oxygen barrier system shall be constructed of non-ferrous or other corrosion resistant materials.

SUBSTANTIATION:
Reference to Figure 408.1(2), as submitted in Item #035 Public Comment 2, will clarify the concept of open expansion storage tanks which are currently allowable under Section 408.1 (Exception 2). This also ties into the definition provided by the USHGC Hydronics Systems Task Group for this type of system configuration.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

COMMITTEE STATEMENT:
Item #040 Public Comment 01 was heard after Item #040 Public Comment 02. Since both comments were “Accepted as Submitted,” the action taken on Item #040 Public Comment 01 prevails.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2
Code Year: 2024 USHGC Section #: 409.4 - 409.4.2
SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

409.0 Materials.

409.4 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.

409.4.1 Vented Atmospheric Closed-Loop Systems. All components installed in a vented closed-loop system shall be constructed of non-ferrous or other corrosion resistant materials.

409.4.2 Non-Oxygen Barrier Closed-Loop Systems. All components installed in a non-oxygen barrier system shall be constructed of non-ferrous or other corrosion resistant materials.

SUBSTANTIATION:
The exception to Section 409.4 (Oxygen Diffusion Corrosion) is being replaced by subsections which specifically address the types of closed-loop systems where the use of "non-ferrous or other corrosion resistant materials" is required. Vented atmospheric closed-loop systems have been included within these subsections to specifically address systems in which the storage component is open to the atmosphere and must be covered under the provisions of "closed-loop systems." Where closed-loop systems experience continual oxygenation, corrosion resistance measures are imperative for thermal efficiency and ultimately system longevity. In efforts to ensure clarity and proper applicability of requirements, both "vented atmospheric closed-loop system" and "non-oxygen barrier closed-loop system" have been appropriately defined in another recommendation provided by this Task Group. Additionally, these requirements correlate with the latest edition of the UMC.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
PUBLIC COMMENT 3

Code Year: 2024 USHGC  Section #: 210.0

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

210.0 - H –

Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

Hydronic System, Atmospheric Closed-Loop. A hydronic system wherein the system fluid may be exposed to the atmosphere.

Hydronic System, Non-Oxygen Barrier Closed-Loop. A hydronic system constructed all or in part with pipe or tubing that is not intended to restrict the diffusion of oxygen into the system fluid.

SUBSTANTIATION:
In support of the other recommendations proposed by this Task Group for Item #040, terminology has been provided for “atmospheric closed-loop hydronic system” and “non-oxygen barrier closed-loop hydronic system.” Both of these definitions are essential to understanding the provisions laid out in Section 409.4.1 (Vented Atmospheric Closed-Loop Systems) and Section 409.4.2 (Non-Oxygen Barrier Closed-Loop Systems) as proposed. The inclusion of such terminology is imperative for interpretation of provisions as well as regulation of the variations of closed-loop systems covered by the USHGC.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Item #: 045
USHGC 2024 Section: 410.9

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

410.0 Joints and Connections.

410.9 Polyethylene of Raised Temperature (PE-RT). Joints between polyethylene of raised temperature (PE-RT) tubing and fittings shall be installed with fittings for PE-RT tubing that comply with the applicable standards referenced in comply with the manufacturer’s installation instructions and the standards listed in Table 409.1. Metal insert fittings, metal compression fittings, and plastic fittings shall be manufactured to and marked in accordance with the standards for fittings in Table 409.1.

SUBSTANTIATION:
The language in Section 410.9 is being reworded for clarity. The revised language ensures that the manufacturer’s installation instructions are followed and that the appropriate industry standards are used.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

EXPLANATION OF AFFIRMATIVE:
FECTEAU: There should be a Public Comment to revise this to use the term "in accordance with." Joints between polyethylene of raised temperature (PE-RT) tubing and fittings shall be installed in accordance with the manufacturers installation instructions and the standards listed in Table 409.1.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC Section #: 410.11
SUBMITTER: Jeff Matson Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

410.0 Joints and Connections.

410.11 Polyethylene of Raised Temperature (PE-RT). Joints between polyethylene of raised temperature (PE-RT) tubing and fittings shall comply be installed in accordance with the manufacturer’s installation instructions and shall comply with the standards listed in Table 409.1. Metal insert fittings, metal compression fittings, and plastic fittings shall be manufactured to and marked in accordance with the standards for fittings in Table 409.1.

SUBSTANTIATION:
The proposed modifications to Section 410.11 [Polyethylene of Raised Temperature (PE-RT)] are being made to clarify that joints between PE-RT tubing and fittings must be “installed” in accordance with manufacturer’s installation instructions. Since PE-RT piping and fittings must “comply” with standards listed in Table 409.1, additional phrasing has been included which states this.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 047
USHGC 2024  Section: 410.15 - 410.15.3

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

410.0 Joints and Connections.

410.13.15 Joints Between Different Materials. Joints between different types of various materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 410.13.1410.15.1 and Section 410.13.2410.15.3.

410.13.1410.15.1 Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints. (remaining text unchanged)

410.13.2410.15.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of plastic or other types of piping material, approved types of listed adapter or transition fittings designed and listed for the specific transition intended shall be used. Except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material.

410.15.3 Stainless Steel to Other Materials. Where connecting stainless steel pipe to other types of piping, mechanical joints of the compression type, dielectric fitting, or dielectric union in accordance with ASSE 1079 and designed for the specific transition intended shall be used.

Note: ASSE 1079 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:
The revisions to Section 410.15.2 are necessary to specify that adapters and transition fittings between different types of plastic, or between plastic and other materials, must be listed and designed for the specific transition intended. These modifications are necessary to ensure proper transition joints and to increase system longevity. Additionally, language has been included to prevent solvent welded joints between PVC and any other unlike materials as this practice is not approved and is essentially an improper use of the product.

Section 410.15.3 is being added to provide the necessary requirements for connections between stainless steel and other types of piping. Since stainless steel is an approved material listed in Table 409.1, the addition of this language supports this already accepted type of material and provides clear requirements which also correlate with the mechanical code.

ASSE 1079 is referenced within Section 410.15.3 as it provides performance requirements for dielectric pipe unions. These devices are metallic and join metallic pipe in a similar manner to standard pipe unions and flanges, with the added ability to electrically insulate one pipe section from another. For these reasons, the proposed modifications are necessary and improve the code.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
410.0 Joints and Connections.

410.15 Joints Between Different Materials. Joints between various materials shall be installed in accordance with the manufacturer's installation instructions and shall comply with Section 410.15.1 and Section 410.15.2.

410.15.1 Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints. Joints from copper or copper alloy pipe or tubing to threaded pipe shall be made by the use of copper alloy adapter, copper alloy nipple [minimum 6 inches (152 mm)], dielectric fitting, or dielectric union in accordance with ASSE 1079. The joint between the copper or copper alloy pipe or tubing and the fitting shall be a soldered, brazed, flared, or pressed joint and the connection between the threaded pipe and the fitting shall be made with a standard pipe size threaded joint.

410.15.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of plastic or other types of piping material, approved listed adapter or transition fittings designed and listed for the specific transition intended shall be used. Except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material.

410.15.3 Stainless Steel to Other Materials. Where connecting stainless steel pipe to other types of piping, mechanical joints of the compression type, dielectric fitting, or dielectric union in accordance with ASSE 1079 and designed for the specific transition intended shall be used:

COMMITTEE STATEMENT:
The term “listed” is being stricken from Section 410.15.2 as this requirement is redundant. Additionally, the proposed Section 410.15.3 (Stainless Steel to Other Materials) is being stricken as dielectric unions may not be applicable to the code, and the inclusion of this section would permit the incorrect application of such joints.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: 410.16 - 410.16.2.1, Table 901.1  Item #: 047
SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

410.0 Joints and Connections.

410.16 Joints Between Different Materials. Joints between various different types of materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 410.16.1 and Section 410.16.2.

410.16.1 Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints. Joints from copper or copper alloy pipe or tubing to threaded pipe of a material other than copper or copper alloy shall be made by the use of copper alloy adapter, copper alloy nipple [minimum 6 inches (152 mm)], dielectric fitting, or dielectric union in accordance with ASSE 1079. The joint between the copper or copper alloy pipe or tubing and the fitting shall be a soldered, brazed, flared, or pressed joint and the connection between the threaded pipe and the fitting shall be made with a standard pipe size threaded joint.

410.16.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of plastic or other types of piping materials, approved adapter or transition fittings designed and listed for the specific transition intended shall be used. Except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material.

410.16.2.1 Transition Joint. For non-pressurized systems rated at 25 psi (172 kPa) or less, a solvent cement transition joint between ABS and PVC drainpipe and fittings shall be made using listed transition solvent cement in accordance with ASTM D3138. PVC and ABS pipe and fittings shall not be solvent welded to any other unlike material.
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 D3138-2021</td>
<td>Standard Specification for Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Non-Pressure Piping Components</td>
<td>Joints</td>
<td>410.16.2.1</td>
</tr>
</tbody>
</table>

Note: ASTM D3138 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:
Section 410.16.1 (Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints) is being revised to include the phrase “of a material other than copper or copper alloy” as the original sentence is unclear and does not specify that the connection is from copper alloy pipe or tubing to threaded pipe of a different material. This revision does not alter the intent of the code section but rather adds clarity to support it.

Section 410.16.2 (Plastic Pipe to Other Materials) revisions include both removal of the last sentence as well as the phrase “and listed.” As required by Section 302.1 (Minimum Standards), “pipe, pipe fittings, appliances, appurtenances, equipment, material, and devices used shall be listed (third party certified) by a listing agency (accredited conformity assessment body) as complying with the approved applicable recognized standards referenced in this code and shall be free from defects.” Therefore, the inclusion of the phrase “and listed” is unnecessary and repetitive.

Regarding the removal of the last sentence to Section 410.16.2, please see the respective requirements provided within the plumbing code:

CHAPTER 3 (GENERAL REQUIREMENTS)
310.0 Prohibited Fittings and Practices
310.10 ABS and PVC Transition Joints. Except as provided in Section 705.9.4, PVC and ABS pipe and fittings shall not be solvent welded to any other unlike dissimilar material.

CHAPTER 6 (WATER SUPPLY AND DISTRIBUTION)
605.16 Joints Between Various Materials.
605.16.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of piping, approved types of adapter or transition fittings designed for the specific transition intended shall be used.

CHAPTER 7 (SANITARY DRAINAGE)
705.9 Special Joints.
705.9.4 Transition Joint. A solvent cement transition joint between ABS and PVC building drain and building sewer shall be made using listed transition solvent cement in accordance with ASTM D3138.

It should be noted that Chapter 7 of the UPC is specific to sanitary drainage systems and such provisions are not applicable for use in hydronic systems. For these reasons, the language which states, “except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material” should be removed from USHGC Section 410.16.2 (Plastic Pipe to Other Materials). In order to generate requirements focusing on non-pressurized lines for condensate drainage on low stakes piping, new Section 410.16.2.1 (Transition Joint) is being proposed. This section addresses solvent cement joints between ABS and PVC and aligns with the referenced standard, ASTM D3138, which is only applicable to non-pressurized systems (rated at 25 psi or less).

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 048
USHGC 2024  Section: 412.4

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

412.0 Pressure and Flow Controls.

412.4 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 the hydronic fluid contains a chemical additive, the potable water supply shall be protected in accordance with Section 402.0.

A pressure-reducing valve shall be installed on a makeup 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.

(Section 402.0 is shown for information purposes 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 Chemical Injection. Additives or chemicals shall be compatible with system components. Where systems include an additive, chemical injection or provisions for such injection, the potable water supply shall be protected by an air gap in accordance with ASME A112.1.2, an air gap fitting listed and labeled in accordance with ASME A112.1.3, or a reduced-pressure principle backflow prevention assembly listed and labeled in accordance with ASSE 1013.

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

402.4 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:
Section 412.4 is being revised to include provisions which protect the potable water supply from contamination. Systems which utilize antifreeze, or any chemical additive, must follow the provisions listed in Section 402.0. This section references the UPC and provides clear requirements for compatibility, backflow prevention, and prohibited sources. For these reasons, the revisions are necessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
412.0 Pressure and Flow Controls.

412.4 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 the hydronic fluid contains a chemical additive, the potable water supply shall be protected in accordance with Section 402.0. A pressure-reducing valve shall be installed on a makeup 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.

COMMITTEE STATEMENT:
The Technical Committee has requested that an editorial revision be made to replace "the potable water supply" with "a potable water supply" throughout the proposals submitted for Chapter 4.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC Section #: 412.4 - 412.4.2 Item #: 048
SUBMITTER: Jeff Matson Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

412.4 Pressure and Flow Controls.

412.4 Automatic Makeup Fluid. Automatic makeup fluid shall be in accordance with Section 412.4.1 for potable water makeup fluid or Section 412.4.2 for nonpotable makeup fluid.

412.4.1 Potable Makeup Fluid. Where an potable water 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 potable water makeup supply shall be located at the expansion tank connection or other approved location. Where the hydronic fluid contains a chemical additive, a potable water supply shall be protected in accordance with Section 402.0. On systems using only water as a heat transfer medium, and where pressurization is achieved using a potable water supply, a pressure-reducing valve shall be installed on a potable water makeup 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.

412.4.2 Nonpotable Makeup Fluid. Makeup fluid systems that are designed to add pre-mixed antifreeze solutions shall be permitted. Such systems shall include, but not be limited to, glycol feeders and limited-volume reservoir systems. On systems using additives, such as glycol or corrosion inhibitors, the use of a system pressurization unit or glycol feeder shall be required.

SUBSTANTIATION:
Section 412.4 (Automatic Makeup Fluid) has been divided to address hydronic systems which use “potable water” or “pre-mixed antifreeze solutions” as automatic makeup fluid.

Section 412.4.1 (Potable Makeup Fluid) includes the necessary revisions to ensure that provisions are explicit to systems in which only potable water is used for makeup fluid. Within this subsection, reference to Section 402.0 (Protection of Potable Water Supply) has been removed and new language specific to potable water makeup feed lines has been provided. During their discussion and review, the Task Group determined that comingling of hydronic fluid and potable water is too great of a health risk to be allowed by any codes, whose primary purpose is that of...
public health and safety. Furthermore, once a system has a final inspection, the code and the Authority Having Jurisdiction no longer have any control over how it is used or maintained. When operation is contingent on the function of disparate components, as opposed to being effected entirely by a listed appliance, there is simply no possibility of legislating the health and safety issues over the lifetime of the installation.

Section 412.4.2 (Nonpotable Makeup Fluid) then addresses makeup fluid systems using premixed antifreeze solutions. In further support of prohibiting comingling of system fluids, this subsection requires the use of either a “system pressurization unit or glycol feeder.” Such devices maintain required fluid pressures and chemical mixtures in closed-loop hydronic systems to compensate for fluid loss during air elimination processes. The use of chemical feeders also addresses issues associated with system fluid dilution which negatively affects the lifespan of hydronic systems.

The Task Group’s public comment submitted on Item #030 further supports this prohibition of comingled system fluids and proposes the necessary revisions to Section 402.0 (Protection of Potable Water Supply).

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

412.0 Pressure and Flow Controls.

412.4 Automatic Makeup Fluid. Automatic makeup fluid shall be in accordance with Section 412.4.1 for potable water makeup fluid or Section 412.4.2 for nonpotable makeup fluid.

412.4.1 Potable Makeup Fluid. Where a potable water 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 potable water makeup supply shall be located at the expansion tank connection or other approved location. On systems using only water as a heat transfer medium, and where pressurization is achieved using a potable water supply, a pressure-reducing valve shall be installed on a potable water makeup 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.

412.4.2 Nonpotable Makeup Fluid. Makeup fluid systems that are designed to add pre-mixed antifreeze solutions shall be permitted. Such systems shall include, but not be limited to, glycol feeders and limited-volume reservoir systems. On systems using additives, such as glycol or corrosion inhibitors, the use of a system pressurization unit or glycol feeder shall be required. The fluid capacity of the tank or reservoir shall not exceed the greater of 5 gallons (19 L), or 5 percent of the total system fluid volume.

COMMITTEE STATEMENT:
Item #048 Public Comment 01 was heard after Item #049 Public Comment 01. Although Item #049 Public Comment 01 was rejected, the committee agrees with the provided limitation on fluid capacity of the tank or reservoir in Section 412.4.2 (Nonpotable Makeup Fluid). This requirement is necessary as it offers additional guidance regarding the fluid capacity of the tank or reservoir for systems using nonpotable makeup fluid. For this reason, Item #048 Public Comment 01 is being modified to include the following language: “The fluid capacity of the tank or reservoir shall not exceed the greater of 5 gallons (19 L), or 5 percent of the total system fluid volume.”

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 049
USHGC 2024  Section: 412.4

SUBMITTER: Mark Eatherton, Advanced Hydronics, Inc.; Ed Shure, Treo Architects LLC; Mark Perry, Mark Perry Construction; Paul Seward, Seward Mechanical Systems

RECOMMENDATION:
Revise text

412.0 Pressure and Flow Controls.

412.4 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 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. Where the system fluid contains a chemical additive, such as antifreeze, a direct connection to a potable water supply system shall not be permitted.

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 accumulated volume of supplied makeup water exceeds the greater of 5 gallons (19 L) or five percent of the total system fluid volume, up to a maximum of 50 gallons (189 L). A manual reset shall be required.

Where an automatic makeup fluid fill device for a closed-loop system is supplied by an isolated tank or reservoir, the fluid capacity of the tank or reservoir shall not exceed the greater of 5 gallons (19 L) or 5 percent of the total system fluid volume, up to a maximum of 50 gallons (189 L).

Exception: In a system in which the volume of introduced makeup fluid is measured and recorded as a function of permanently installed system controls, the automatic fluid volume cutoff limitation shall not be required.

SUBSTANTIATION:
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. 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 possible.

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.

This proposal does not mandate installation of a makeup supply with a permanent connection to a water supply. This proposal has the explicit intent to limit large-scale consequential water damage to the structure, as a result of a breached hydronic system. Leak detection as a feature is neither implicit nor explicit in the proposed language, and is therefore irrelevant to the consideration of this proposal. This proposal also is explicitly limited to closed-loop systems, and therefore has no applicability to the makeup supply to steam generating boilers.
Any hydronic system installed per the USHGC must have protections against boiler operation (Sections 412.2 & 412.3) if a low-water condition and or a low-flow condition is detected. Some industry manufacturers recommend using a pressure reducing or automatic feed valve ONLY for the initial fill and system setup, and then closing the required isolation valve to deny makeup fluid during system operation. This is actually very common in the EU, with no adverse consequences. It does mean that human intervention is required for system pressure maintenance. Isolation valves are required on both sides of a pressure-reducing valve (i.e. automatic fill valve) such as installed on a permanent makeup supply line, per Section 312.5. If there were to be an exception in this proposal for that configuration, additionally requiring that the system be operated with the valve closed, it would be unenforceable, ignorable in practice, and would therefore make this proposed language totally moot.

This proposal also specifically addresses and encourages the rarely seen or understood trade practice of use of a system feeder, in lieu of an automatic feed valve, for the purpose of limiting water release. There are also systems using a second expansion tank as a volume-limiting makeup fluid reservoir. Encouraging the use of feeders or reservoirs ties into the objectives of the newly created heat transfer fluid quality standard, IAPMO H1001.1-2021. Of note is the 5% volume limitation on makeup in this standard. Data on existing systems shows that actual makeup volumes are typically 0.25% to 0.5% annually; so that a 5% limitation gives a very generous buffer.

A volume limitation for makeup fluid, as a percentage of total system volume, has the intent to address and allow for the usual losses of larger volume systems. The impeller-type circulator pumps typically found in hydronic systems will cavitate to the point of air lock at an air/gas content of about 4% by volume, thus the allowance of 5% for a makeup fluid volume, without intervention.

At this time, there is a device available in Europe at a cost of about $600, which offers automatic makeup fill along with a limitation on the volume of water release. This device easily meets the requirements of the proposed new language, should an installer choose to connect to a potable water distribution system. This device has no known patent protections, such that equivalent technology could easily be introduced by other entities to the US, without restriction. It is important to note that this type of device is not required to meet the proposed code change, but would be entirely discretionary.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is overly stringent and is more of a best practice rather than basic health and safety requirements. This change will also conflict with Section 402.0 (Protection of Potable Water Supply) regarding connections to the potable water supply. Item #049 is being rejected as the intent of the section is better covered in Item #048.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC Section #: 412.4 - 412.4.2

SUBMITTER: Lee Stevens
LH Stevens Construction LLC

RECOMMENDATION: Accept as Modified
Request to replace the code change proposal by this public comment.

412.0 Pressure and Flow Controls.

412.4 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 the hydronic fluid contains a chemical additive, a potable water supply shall be protected in accordance with Section 402.0.

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

Automatic makeup fluid shall be in accordance with Section 412.4.1 for potable water makeup fluid or Section 412.4.2 for nonpotable makeup fluid.

412.4.1 Potable Makeup Fluid. Where potable water or a potable water supply is used for makeup fluid, the makeup water quality shall meet the requirements of IAPMO/ANSI H1001.1 and Section 401.6.

Where an automatic makeup water supply fill device for a closed-loop system is supplied by a potable water supply, the system shall be filled, purged, and commissioned. Thereafter, the fill system shall automatically shut off the makeup supply when the accumulated volume of supplied makeup water reaches the greater of 5 gallons (19 L), or 5 percent of the total system fluid volume. A manual reset of this limit shall be required in order to allow subsequent additions of makeup fluid.

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

Exception: In a system in which the volume of introduced makeup fluid is measured and recorded as a function of permanently installed system controls, the automatic fluid volume cutoff limitation shall not be required.

412.4.2 Nonpotable Makeup Fluid. On systems using additives, such as glycol or corrosion inhibitors, the use of a system pressurization unit or glycol feeder shall be required. The makeup fluid quality shall meet the requirements of IAPMO/ANSI H1001.1 and Section 401.6. Such makeup systems shall include, but not be limited to, glycol feeders and limited-volume reservoir systems. The fluid capacity of the tank or reservoir shall not exceed the greater of 5 gallons (19 L), or 5 percent of the total system fluid volume.

(below shown for information purposes only)

401.6 Heat Transfer Fluid Quality. Heat transfer fluids used in closed-loop hydronic systems shall be in accordance with IAPMO/ANSI H1001.1.

Note: IAPMO/ANSI H1001.1 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:
By incorporating IAPMO/ANSI H1001.1 (Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems) into the code as a requirement, water quality is now mandated, with implications for the makeup supply. The limitation of no more than 5% makeup, by volume annually, has several purposes. This ensures basic system fluid quality, controls dilution in systems with chemical additives, and has the added benefit of limiting consequential water damage in the event of a breached or damaged system. It is important to differentiate between the use of potable water (of acceptable quality standards) and a connection to a potable (pressurized) potable water supply (also only if of acceptable water quality).

The general thrust of this standard is towards isolation of hydronic systems from a potable water supply, which is encouraged by the use of system feeders. This should be further encouraged by putting makeup volume limitations on potable water supply makeup systems as well, for all of the previously stated reasons. The intent of this language is to trigger the makeup limitation only after a successful start-up of the system, so that true and necessary makeup volume is what is being limited. It is also important to maintain the essential requirements for the location of the makeup connection, and for pressure control, whether the makeup supply is from a pressurized domestic potable system, a system feeder with a pump, or other equivalent makeup supply system.

This wording makes clear that systems that use chemical and glycol mixes must use a feed system that introduces makeup fluid of acceptable characteristics and will not create a dilution issue over the long term. Research shows that undamaged hydronic systems will typically require about 0.5% makeup fluid by volume, annually. It is also shown that municipal water supplies are typically under 2% entrained air by volume. The 5% makeup allowance can easily replace the entrained air volume, and typically still provide at least five years makeup supply requirements, so this limitation is not an undue burden on the installer or facility owner.
The volume limitation for potable supply sources can be realized with currently available off the shelf components, such as are used in the irrigation controls industry. A system catastrophically damaged, such as by pipes freezing and splitting, can result in very significant and far more consequential damage. This can render a structure uninhabitable, at least over the short term, and can be greatly minimized by the makeup volume limitation, which can prevent unlimited flooding and destruction of the structure.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #049 Public Comment 01 was heard before Item #048 Public Comment 01. Item #049 Public Comment 01 is being rejected as the proposed makeup limitations in Section 412.4.1 (Potable Makeup Fluid) serve more as best practices rather than minimum requirements. Furthermore, this provision would require a separate device in order to meet the specified makeup limitation, and although the committee agrees with the intent of providing a makeup limitation, there are concerns regarding the availability of such devices to installers, making the provisions impractical.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 056
USHGC 2024  Section: 417.2.4

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

417.0 Snow and Ice Melt Systems.

417.2.4 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 subgrade and be extended as close as practicable to the outside edges of the concrete.

SUBSTANTIATION:
The minor revision to Section 417.2.4 is needed to clarify that insulation is to be installed between the subgrade and the concrete. Since "grade" is technically a rating while "subgrade" is the layer of soil on which foundation is laid, such distinction is necessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS:  AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 221.0
SUBMITTER: Jazmin Curiel
Self

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

221.0  - S -
Subgrade. A layer, stratum, or material (typically soil or natural ground) which has been compacted and prepared to support the foundation of an engineering structure.

SUBSTANTIATION:
A definition for "subgrade" offers needed clarity when interpreting the provisions of the USHGC. The term subgrade is used throughout the code, and appropriate terminology would be beneficial in Chapter 2 (Definitions). The proposed description includes sufficient information to understand the difference between grade and subgrade.
COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #056 Public Comment 01 is being rejected as the inclusion of a definition for “subgrade” is unnecessary. Such terminology does not improve or enhance the code. Although the term “subgrade” is used once in the code, it is considered common industry terminology and does not require a technical description within the USHGC.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2

Item #: 056
Comment #: 2

Code Year: 2024 USHGC  Section #: 417.2.6

SUBMITTER: Jeff Matson
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

417.0 Snow and Ice Melt Systems.

417.2 Snow and Ice Melt Controls. (remaining text unchanged)

417.2.6 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 subgrade and be extended as close as practicable to the outside edges of the concrete.

   Exception: An approved engineered alternative method of construction in accordance with Section 302.2.

   (below shown for information purposes only)

302.2 Alternate Materials and Methods of Construction Equivalency. Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire-resistance, effectiveness, durability, and safety over those prescribed by this code. Technical documentation shall be submitted to the Authority Having Jurisdiction to demonstrate equivalency. The Authority Having Jurisdiction shall have the authority to approve or disapprove the system, method, or device for the intended purpose. However, the exercise of this discretionary approval by the Authority Having Jurisdiction shall have no effect beyond the jurisdictional boundaries of said Authority Having Jurisdiction. An alternate material or method of construction so approved shall not be considered as in accordance with the requirements, intent, or both of this code for a purpose other than that granted by the Authority Having Jurisdiction where the submitted data does not prove equivalency.

SUBSTANTIATION:
Section 417.2.6 (Insulation) is being revised to include an exception for approved engineered alternative methods of construction in compliance with Section 302.2 (Alternate Materials and Methods of Construction Equivalency). Providing an insulation requirement is acceptable, however R-values vary based on geographical location. Design should be based on local conditions, and therefore such requirements should align with the building code or energy code as adopted by the Authority Having Jurisdiction. For this reason, the exception is necessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 057
USHGC 2024  Section: 418.2.3

SUBMITTER: Jeff Matson  
Chair, USHGC Hydronics Systems Task Group

RECOMMENDATION:
Revise text

418.0 Piping Installation.

418.2 Embedded Piping Materials and Joints. (remaining text unchanged)

418.2.3 Plastics. Plastic pipe and tubing shall be installed in continuous lengths or shall be joined by heat fusion methods or other approved fittings in accordance with Table 409.1 and the manufacturer’s installation instructions. 
Exception: Solvent cement joints shall not be used in embedded applications.

SUBSTANTIATION:
The proposed revision is needed to clarify that the language is a requirement rather than an exception.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 212.0

SUBMITTER: Jim Majerowicz  
Plumbers Local Union 130 U.A.

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

212.0  - J -
Joint, Heat Fusion. A joint used in some thermoplastic systems to connect the pipe to fittings or pipe lengths directly to one another (butt-fusion). This method of joining pipe to fittings includes butt-fusion, socket-fusion, electro-fusion, and saddle-fusion. This method of welding involves the application of heat and pressure to the components, allowing them to fuse together forming a bond between the pipe and fitting.
SUBSTANTIATION:
This code change is for correlation with the Uniform Mechanical Code. The USHGC currently contains definitions for the following joint types: brazed, compression, flanged, flared, mechanical, soldered, and welded. As heat fusion joints are referenced in various hydronics and geothermal energy system provisions, it would also be suitable to include the proposed definition within Chapter 2 (Definitions).

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 059
USHGC 2024  Section: 501.5

SUBMITTER: Adam Chrisman
Chair, USHGC Solar Thermal Systems Task Group

RECOMMENDATION:
Revise text

501.0 General.

501.5 Materials. Piping, tubing and fittings materials shall comply with Table 409.1 and shall be approved by the manufacturer for the intended application. Joining methods shall be in accordance with Section 410.0. Materials in contact with heat transfer medium shall be approved for such use. Galvanized steel shall not be used for solar thermal piping systems containing antifreeze. Black steel shall not be used in systems with entrapped or entrained air. Unions between dissimilar metals shall comply with Section 305.2 and Section 410.13. The material used shall be capable of withstanding the maximum temperature and pressure of the system.

SUBSTANTIATION:
Although Table 409.1 (Materials for Hydronic and Solar Thermal System Piping, Tubing, and Fittings) includes approved material standards, a specification should also be included to ensure that the materials being used are approved by the manufacturer.

Entrained air refers to air bubbles smaller than 0.04 inch, and any air bubbles larger are considered entrapped. Including both of these terms is appropriate and provides additional clarity.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

501.0 General.

501.5 Materials. Piping, tubing and fitting materials shall comply with Table 409.1 and shall be approved by the manufacturer for the intended application. Joining methods shall be in accordance with Section 410.0. Materials in contact with heat transfer medium shall be approved for such use. Galvanized steel shall not be used for solar thermal piping systems containing antifreeze. Black steel shall not be used in systems with entrapped or entrained air. Unions between dissimilar metals shall comply with Section 305.2 and Section 410.13. The material used shall be capable of withstanding the maximum temperature and pressure of the system.

COMMITTEE STATEMENT:
The term “approved” is being changed to “identified” since approval is a defined term that puts the responsibility on the Authority Having Jurisdiction. The term “identified” is better suited for recommendations provided by the manufacturer.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS:  AFFIRMATIVE: 16
EXPLANATION OF AFFIRMATIVE:

FECTEAU: There should be a Public Comment to introduce a definition for the term "identified." This is the definition of the term identified out of the 2020 NEC; Identified (as applied to equipment). Recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular Code requirement.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 211.0

SUBMITTER: Jeffrey Fecteau
UL LLC

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

211.0 – I –
Identified (as referenced to equipment and materials), Recognized as being suitable for the specific application, environment, function, installation, purpose, use, and so forth, where described in a particular code requirement.

SUBSTANTIATION:
The term "identified" should be defined in Chapter 2 (Definitions), Section 211.0 (-I-).

The committee statement for Items #059, #060, #076, #078, and #085 states that "the term 'identified' is better suited for recommendations provided by the manufacturer."

However, a product may be required to be identified for a specific use by a requirement of an applicable product standard such as UL 778 (Standard for Safety for Motor-Operated Water Pumps). UL 778 as an example requires that the literature accompanying a pump identifies the intended use such as condensate, effluent, sump, fountain, irrigation, deep well, shallow well or as water circulating pump. UL 778 additionally states that a pump intended for use with liquids other than water, is required to be evaluated based on its compliance UL 778, and further examination and tests are required to determine whether it is acceptable for the purpose. This would include, but not be limited to, pumps intended for water/glycol and similar mixtures intended for use in hot water radiant heating or thermal solar applications.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 061
USHGC 2024 Section: 501.7

SUBMITTER: Adam Chrisman
Chair, USHGC Solar Thermal Systems Task Group

RECOMMENDATION:
Delete text without substitution

501.0 General.

501.7 Drainback Systems. The circulating pump shall be sized to overcome the static head pressure height of the collector, pressure losses, and provide the required flow rate to the collector. The drainback reservoir shall be located in a conditioned space to prevent freezing. A sight glass, or other method of monitoring the level of fluid in the solar loop shall be installed in the solar loop, or on the drainback reservoir. A drainback system shall be capable of being manually isolated and drained.

SUBSTANTIATION:
The provisions listed for drainback systems read similarly to terminology rather than requirements. Additionally, the language is unclear, and requiring drainback vessels to be in a conditioned space is impractical and overly restrictive. For these reasons, the provisions for drainback systems are being stricken.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Item #: 061

SUBMITTER: Monte Myers
Self

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

206.0 - D - Drainback System. A closed-loop solar thermal system, which allows gravity draining of the heat transfer fluid into lower portions or in which the heat transfer fluid is drained by gravity from the collector to the storage tank, the solar loop under prescribed circumstances.
310. Circulators and Pumps.

310.4 Drainback Systems. For drainback solar thermal systems, a circulator without a check valve shall be installed.

(renumber remaining sections)

501.0 General.

501.4 Draining. Solar thermal system piping shall be installed to permit draining of the system. Drainback system piping shall be in accordance with Section 501.7.

501.7 Drainback Systems. Drainback systems shall be designed and installed to drain by gravity and shall be capable of being manually isolated and drained. Means shall be provided for air filling after draining and air venting after refilling. Drainback system piping above the fluid level of the drainback reservoir shall have a slope of not less than ¼ inch per foot (20.8 mm/m). Circulating pumps shall comply with Section 501.13. Drainback systems shall not require an expansion tank or air removal device.

(renumber remaining sections)

501.12 Freeze Protection. (remaining text unchanged)

501.12.2 Drainback. Drainback systems shall drain by gravity and shall be permitted to be installed in applications not be installed where the ambient temperature is not less than -60°F (-51°C).

501.13 Circulators. Circulating pumps shall be installed in accordance with Section 310.0. For drainback systems, the pump shall overcome the total head of the system while maintaining the required collector flow rate. A circulator without a check valve shall be installed, and the pump shall be sized to overcome the static head pressure height of the collector, overcome pressure losses, and provide the required flow rate to the collector. For other systems, the pump shall be sized to overcome the friction head of the system while maintaining the required collector flow rate.

(below shown for information purposes only)

408.0 Expansion Tanks.

408.1 General. An expansion tank shall be installed in each hydronic closed-loop system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed type, incorporating a diaphragm or bladder to ensure the isolation of the system fluid from the pre-charge gas or from the atmosphere. Plain compression tanks shall not be permitted. Expansion tanks shall be rated for the pressure of the system.

Exceptions:
(1) Drainback type solar thermal systems shall not require a hydronic expansion tank.
(2) An engineered fluid expansion storage system shall be permitted to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion.

412.0 Pressure and Flow Controls.

412.6 Air-Removal Device. Provision shall be made for the removal of air from fluid in hydronic systems. Air removal devices shall be located in the areas of the hydronic piping system where air is likely to accumulate. Air-removal devices shall be installed to facilitate their removal for examination, repair, or replacement.

Exception: Drainback type solar thermal systems shall not require an air-removal device.

SUBSTANTIATION:
The existing requirements for drainback systems are scattered throughout the code. This recommendation includes a reorganization of those requirements along with a revised definition which more accurately describes these systems. For the purposes of the USHGC, a drainback system should be defined as “a closed-loop solar thermal system in which the heat transfer fluid is drained by gravity from the collector to the storage tank under prescribed circumstances.”

The provisions in Section 310.4 (Drainback Systems) are being relocated to Section 501.13 (Circulators) where additional requirements already exist. Rather than needing to refer to both Section 310.4 and this section, combining the provisions allows for easier interpretation of requirements.
Section 501.7 (Drainback Systems) addresses design and installation requirements and refers to the revised Section 501.13 (Circulators) for circulator requirements. The last sentence of the section reiterates that these systems do not require expansion tanks or air removal devices, as dictated in the exceptions to Section 408.1 (Expansion Tanks - General) and Section 412.6 (Air-Removal Device). Since this section addresses the design and installation of these systems, Section 501.12.2 (Drainback) needs to only specify that these systems cannot be installed where the ambient temperature is less than -60F.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #061 Public Comment 01 is being rejected as the listed provisions for drainback systems are unclear, unenforceable, impractical, and overly restrictive. The proposed language regarding drainback systems aligns better with terminology rather than requirements. In support of this rejection, the committee refers to both the substantiation and action taken on Item #061 which removed the existing provisions for drainback systems during the proposal stage.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:   AFFIRMATIVE: 16
Proposals

Item #: 072
USHGC 2024  Section: 606.5, Table 901.1

SUBMITTER: Lance MacNevin
Plastics Pipe Institute

RECOMMENDATION:
Revise text

606.0 Dry Storage Systems.

606.5 Combustibles Within Ducts or Plenums. Materials exposed within ducts or plenums shall be noncombustible or shall have a flame spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested as a composite product in accordance with ASTM E84 or UL 723. Exception: Plastic pipe and tubing listed and labeled in accordance with UL 2846 as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm). Plastic pipe and tubing shall also be installed in accordance with its listing.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>UL 2846-2014</td>
<td>Fire Test of Plastic Water Distribution Plumbing Pipe for Visible Flame and Smoke Characteristics (with revisions through January 14, 2021)</td>
<td>Piping</td>
<td>606.5</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 2846 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:
UL 2846 was developed by UL specifically for testing plastic piping materials. This standard is a test method for determining values of flame propagation distance and optical smoke density for individual pairs of plastic plumbing pipes for distribution of potable water, and water used for hydronic heating and cooling applications, water reclaim/reuse water applications.

The requirements within UL 2846 are no less stringent than the requirements listed within ASTM E84, and the mounting methods to be used when testing the plastic piping are specifically described for consistent testing and interpretation of the results by enforcement agencies.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
606.0 Dry Storage Systems.

606.5 Combustibles Within Ducts or Plenums. Materials exposed within ducts or plenums shall be noncombustible or shall have a flame spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested as a composite product in accordance with ASTM E84 or UL 723.

Exception: Plastic pipe and tubing listed and labeled for use in plenums in accordance with UL 2846 as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm). Plastic pipe and tubing shall also be, and installed in accordance with its listing, shall be permitted.

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(portion of table not shown remains unchanged)

COMMITTEE STATEMENT:
The exception is being modified to provide needed clarity. The language now specifies that the exception applies only to piping and tubing used in plenums. Such revisions are also consistent with the recent action taken by the UMC Technical Committee for Item #141 Public Comment 2.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 606.5  Item #: 072
SUBMITTER: Arnold Rodio  Chair, USHGC-USPSHTC Technical Correlating Committee  Comment #: 1

RECOMMENDATION: Accept as Modified

Request to accept the code change proposal as modified by this public comment.

606.0 Dry Storage Systems.

606.5 Combustibles Within Ducts or Plenums. Materials exposed within ducts or plenums shall be noncombustible or shall have a flame spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested as a composite product in accordance with ASTM E84 or UL 723. Mounting methods, supports, and sample sizes of materials for testing that are not specified in ASTM E84 or UL 723 shall be prohibited.

Exception: Plastic pipe and tubing listed and labeled for use in plenums in accordance with UL 2846 as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm), and installed in accordance with its listing, shall be permitted.

Note: ASTM E84 and UL 723 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 USHGC-USPSHTC TCC has generated a recommendation for USHGC Item # 072, Section 606.5 (Combustibles Within Ducts or Plenums) to be submitted as a USHGC Public Comment for consideration at the next USHGC TC meeting. The recommendation prohibits the use of testing materials that are not specified in ASTM E84 or UL 723. The TCC recommendation correlates with the action taken by the UMC TC to “accept as submitted” Item # 141 Comment 2 as published in the 2022 UMC Report on Comments.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #072 Public Comment 01 is being rejected as the proposed language in Section 606.5 (Combustibles Within Ducts or Plenums) is unenforceable. Neither ASTM E84 nor UL 723 mention any type of mounting methods or supports, and these standards were originally intended only for flat-sheet products. Therefore, the references to ASTM E84 and UL 723 are inappropriate for the listed application.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
CHAPTER 7
GEOTHERMAL ENERGY SYSTEMS AND DISTRICT GEOTHERMAL LOOPS

Part I – General.

701.0 General.
701.1 Applicability. Part I of 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.

Part I through Part V of this chapter shall apply to geothermal energy systems and district thermal systems that circulate ground-ambient-temperature water to be used in end-use buildings as a thermal source or sink via water source heat pump or reversing chiller. The systems shall operate to permit independent and bi-directional heating and cooling for comfort and water heating such as, but not limited to, building systems coupled with ground coupled district loops, a ground-heat exchanger, submerged heat exchanger using water-based fluid as a heat transfer medium, or groundwater (well), or such local resources to the advantage of the district. Central district auxiliary components shall add or reject heat to benefit district ability, to reduce both power consumption, and demand combined with energy sharing. The regulations of this chapter shall govern the construction, location, and installation of ground temperature thermal distribution districts from 100 percent geothermal energy systems to multiple hybrid district systems. (See Figure 701.1 for a schematic of a geothermal system utilizing an ambient temperature loop.)

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

SUBSTANTIATION:
Section 701.1 (Applicability) is being revised to provide insight into the various parts of Chapter 7 pertaining to general requirements, open-loop systems, closed-loop systems, DX systems, and now district ambient temperature loops. The addition of geothermal district systems supports advanced thermal distribution networks and provides the code with the necessary requirements for large scale renewable energy systems.

Furthermore, the language pertaining to indoor piping, fittings, and accessories has been moved from the applicability to Section 701.1.3 (Indoor Piping) as this allows for proper flow of requirements.

COMMITTEE ACTION: REJECT
COMMITTEE STATEMENT:
The Technical Committee has requested that additional time be provided to review the proposed requirements for
district systems and ambient temperature loops. The Technical Committee will submit all comments and concerns
via their letter ballots for Item #073, Item #074, Item #094, Item #095, Item #096, Item #097, and Item #098. It is
recommended that the Geothermal Energy Systems Task Group reconvene to address all submitted feedback and
resubmit proposals via public comments.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
EXPLANATION OF AFFIRMATIVE:
SMITH: This item is part of a multiple submission to update Chapter 7 and should not have been rejected but may
need to be modified by the subcommittee and resubmitted in public comment.

Appended Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: 701.1, 701.1.3  Item #: 073
SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group
Comment #: 1
RECOMMENDATION: Accept as Modified

Request to replace the code change proposal by this public comment.

CHAPTER 7
GEOTHERMAL ENERGY SYSTEMS AND DISTRICT GEOTHERMAL LOOPS

Part I – General.

701.0 General.
701.1 Applicability. Part I of 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.

Part I through Part V of this chapter shall apply to geothermal energy systems and district systems that circulate ground-
ambient-temperature water, conditioned water, or heat transfer fluid, to be used in end-use buildings as a thermal source
or sink via water source heat pump or reversing chiller. The systems shall operate to permit independent and bi-
directional heating and cooling for comfort and water heating such as, but not limited to, building systems with ground
coupled district loops, including ambient temperature loops (ATL), a ground-heat exchanger, submerged heat exchanger
using water-based fluid as a heat transfer medium, or groundwater (well), or such local energy resources to the
advantage of the district. Central district auxiliary components shall add or reject heat to benefit district ability to reduce
both power consumption and demand combined with energy sharing.

The regulations of this chapter shall govern the construction, location, and installation of ground temperature thermal
distribution districts from 100 percent geothermal energy systems to multiple hybrid district systems, including systems
which utilize multiple hybrid district systems and components.

701.1.3 Indoor Piping. Indoor piping, fittings, and accessories that are part of the groundwater system shall be in
accordance with Section 703.5 and Chapter 4.
SUBSTANTIATION:
Section 701.1 (Applicability) is being revised to provide insight into the various parts of Chapter 7 pertaining to general requirements, open-loop systems, closed-loop systems, DX systems, and now ambient temperature loops. The addition of geothermal district systems supports advanced thermal distribution networks and provides the code with the necessary requirements for large scale renewable energy systems.

The second paragraph has been revised from the original proposal to also include the phrase “conditioned water or heat transfer fluid.” This new phrasing now addresses geothermal energy systems and district systems that circulate fluids other than just ground-ambient temperature water.

The third paragraph of Section 701.1 (Applicability) has also been further revised to address systems that utilize multiple hybrid district systems and components. Furthermore, the language pertaining to indoor piping, fittings, and accessories has been moved from the applicability to Section 701.1.3 (Indoor Piping) as this allows for proper flow of requirements.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2

Code Year: 2024 USHGC  Section #: 221.0  Item #: 073

SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group  Comment #: 2

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

221.0 - S -
Submerged Heat Exchanger. A closed-loop heat exchanger submerged in water or a fluid. Some examples include, but are not limited to, lake or pond heat exchangers, sanitary waste heat recovery systems, downhole heat exchangers, and standing column well heat exchangers.

SUBSTANTIATION:
The term “submerged heat exchanger” is used throughout Chapter 7 (Geothermal Energy Systems) and requires an appropriate definition to provide clarity for users of the code. The provided definition offers both a clear depiction of this type of heat exchanger as well as several examples. It was necessary to clarify that these heat exchangers are submerged in water or fluid since there exist various applications, some of which include heat recovery from fluids other than water. As heat recovery applications expand, it is beneficial to be inclusive of emerging technologies which may be utilized.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
PUBLIC COMMENT 3

Code Year: 2024 USHGC  Section #: 701.3  Item #: 073

SUBMITTER: Jeff Persons  Self

RECOMMENDATION: Accept as Modified

Request to **replace** the code change proposal by this public comment.

701.0 General.

701.3 Site Survey. A site survey shall be conducted prior to designing the geothermal system. The requirements for construction documents shall be defined by the Authority Having Jurisdiction. Where no guidance is provided, the following information shall be provided:

- Construction documents shall include the dimensions and location of the ground heat exchanger and the dimensions from the building to the water well, ground heat exchanger, or submerged heat exchanger.
- Grout or sealing specifications, as applicable.
- Dimensions from building to water well, ground heat exchangers, or submerged heat exchanger.
- Operating temperatures and pressures.

**SUBSTANTIATION:**

A site survey is intended to establish the practicality and location of a ground heat exchanger installation in relation to the property and structures that exist or will be constructed on that property. Grouting specifications and operating temperatures are more related to project specifications and commissioning and should not be considered as details needed for a site survey.

**COMMITTEE ACTION:** ACCEPT AS AMENDED BY THE TC

701.0 General.

701.3 Site Survey. A site survey shall be conducted prior to designing the geothermal system. The requirements for construction documents shall be defined by the Authority Having Jurisdiction. Where no guidance is provided, the construction documents shall include a plat plan indicating the following:

- The dimensions and location of the ground or submerged heat exchanger and the dimensions from the building to the water well, ground heat exchanger, or submerged heat exchanger.
- The distance from the structure to the ground or submerged heat exchanger.
- The configuration and depth of the ground or submerged heat exchanger.
- The distance to any utility and sanitary features that exist near the ground or submerged heat exchanger.

**COMMITTEE STATEMENT:**

Item #073 Public Comment 03 is being modified to further expand on the information to be provided within the construction documents. A site survey is intended to establish the practicality and location of a ground heat exchanger installation in relation to the property and structures that exist or will be constructed on that property. Grouting specifications and operating temperatures are more related to project specifications and commissioning and should not be considered as details needed for a site survey. The inclusion of the geothermal ground exchanger location on the project Plat Plan provides a reference to its location by all contractors doing site work on a project.

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 077
USHGC 2024  Section: Table 703.2, Table 703.3

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Revise text

TABLE 703.2
PLASTIC GROUND SOURCE LOOP PIPING

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linked Polyethylene (PEX)</td>
<td>ASTM F876, [ASTM F3253], CSA B137.5,</td>
</tr>
<tr>
<td></td>
<td>CSA/IGSHPA C448, NSF 358-3</td>
</tr>
<tr>
<td>Polyethylene of Raised Temperature (PE-RT)</td>
<td>ASTM F2623, ASTM F2769, CSA B137.18,</td>
</tr>
<tr>
<td></td>
<td>CSA/IGSHPA C448, NSF 358-4</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

TABLE 703.3
GROUND SOURCE LOOP PIPE FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linked Polyethylene (PEX)</td>
<td>ASTM F877, ASTM F1055, ASTM F1807, ASTM F1960,</td>
</tr>
<tr>
<td></td>
<td>ASTM F2080, ASTM F2159, ASTM F2434, [ASTM F3253],</td>
</tr>
<tr>
<td></td>
<td>ASTM F3347, ASTM F3348, CSA B137.5, CSA/IGSHPA C448, NSF 358-3</td>
</tr>
<tr>
<td>Polyethylene of Raised Temperature (PE-RT)</td>
<td>ASTM D3261, ASTM F1055, ASTM F1807, ASTM F2080,</td>
</tr>
<tr>
<td></td>
<td>ASTM F2159, ASTM F2769, [ASTM F3347, ASTM F3348],</td>
</tr>
<tr>
<td></td>
<td>CSA B137.18, CSA/IGSHPA C448, NSF 358-4</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ASTM F3347 and ASTM F3348 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:
ASTM F3253 is being removed as this standard is applicable to oxygen barrier crosslinked polyethylene (PEX) tubing which is not used in geothermal applications. Additionally, ASTM F3347 and ASTM F3348 are being added for PE-RT pipe fittings. ASTM F3347 covers copper alloy metal press insert fittings while ASTM F3348 covers plastic press insert fittings. These fittings are for use with cross-linked polyethylene (PEX) tubing that meets the requirements of ASTM F876 and polyethylene of raised temperature (PE-RT) tubing that meets the requirements of ASTM F2769. Such fittings are intended for use in 100 psi (689.5 kPa) hot and cold water distribution systems operating at temperatures up to, and including, 180°F (82°C). ASTM F3347 and ASTM F3348 are already listed in Table 703.3 for PEX pipe fittings and should also be included for PE-RT.
TABLE 703.2
Plastic Ground Source Loop Piping

<table>
<thead>
<tr>
<th>Material</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linked Polyethylene (PEX)</td>
<td>ASTM F876, [<strong>ASTM F3253</strong>], CSA B137.5,</td>
</tr>
<tr>
<td></td>
<td>CSA/IGSHPA C448, NSF 358-3</td>
</tr>
<tr>
<td>Polyethylene of Raised Temperature (PE-RT)</td>
<td>ASTM F2623, ASTM F2769, CSA B137.18,</td>
</tr>
<tr>
<td></td>
<td>CSA/IGSHPA C448, NSF 358-4</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

TABLE 703.3
Ground Source Loop Pipe Fittings

<table>
<thead>
<tr>
<th>Material</th>
<th>Standards</th>
</tr>
</thead>
</table>

(portion of table not shown remains unchanged)

**Committee Statement:**
ASTM F3253 is being kept as this standard is applicable to oxygen barrier crosslinked polyethylene (PEX) tubing used in geothermal applications. Keeping this standard prevents materials from being excluded which may be appropriate for use.

**Total Eligible to Vote:** 16

**Voting Results:** **Affirmative:** 16

**Explanation of Affirmative:**
**Macnevin:** ASTM F3253 PEX tubing probably should not be included in these geothermal tables, but we can review that during public comment.
Request to accept the code change proposal as modified by this public comment.

### TABLE 703.2
**PLASTIC GROUND SOURCE LOOP PIPING**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linked Polyethylene (PEX)</td>
<td>ASTM F876, ASTM F3253, CSA B137.5,</td>
</tr>
<tr>
<td></td>
<td>ANSI/CSA/IGSHPA C448, NSF/ANSI 358-3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

### TABLE 703.3
**GROUND SOURCE LOOP PIPE FITTINGS**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linked Polyethylene (PEX)</td>
<td>ASTM F877, ASTM F1055, ASTM F1807,</td>
</tr>
<tr>
<td></td>
<td>ASTM F1960, ASTM F2080, ASTM F2159,</td>
</tr>
<tr>
<td></td>
<td>ASTM F2434, ASTM F3253, ASTM F3347,</td>
</tr>
<tr>
<td></td>
<td>ASTM F3348, CSA B137.5, ANSI/CSA/IGSHPA C448,</td>
</tr>
<tr>
<td></td>
<td>NSF/ANSI 358-3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**SUBSTANTIATION:**

ASTM F3253 is being removed as this standard is applicable to oxygen barrier crosslinked polyethylene (PEX) tubing which is not used in geothermal applications. Since this standard is not applicable to geothermal ground-loop system piping, there is no practical reason to include it within Table 703.2 (Plastic Ground Source Loop Piping) or Table 703.3 (Ground Source Loop Pipe Fittings).

As stated in the scope of ASTM F3253, “This specification covers requirements, test methods, and marking requirements for crosslinked polyethylene (PEX) tubing with a polymeric oxygen barrier layer, made in one standard dimension ratio (SDR 9), and distribution system components intended for hydronic heating and cooling applications up to and including a maximum working temperature of 200 °F (93 °C).”

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 079
USHGC 2024  Section: 703.4.1, Table 703.4.1, 710.3

SUBMITTER: Lance MacNevin
Plastics Pipe Institute

RECOMMENDATION:
Revise text

Part I – General.

703.0 Design of Systems.

703.4 Underground Piping and Submerged Materials. (remaining text unchanged)
703.4.1 Polyethylene (PE). Polyethylene pipe or tubing shall be manufactured in accordance with the standards listed in Table 703.2. Pipe or tubing 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).

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/AWWA C901. Polyethylene pipe or tubing shall have a minimum wall thickness in accordance with Table 703.4.1.

<table>
<thead>
<tr>
<th>PE PIPE MATERIAL</th>
<th>MINIMUM WALL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE 3608</td>
<td>SDR 11</td>
</tr>
<tr>
<td>PE 4710</td>
<td>SDR 13.5</td>
</tr>
</tbody>
</table>

Part II – Closed-Loop Systems.

710.0 General.
710.3 Borehole Piping and Tubing. Borehole piping or tubing for vertical and horizontally drilled closed-loop systems, shall have a minimum wall thickness in accordance with Table 703.4.1 equal to SDR-11 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Note: AWWA C901 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:
This proposal recognizes the fact that PE compounds PE 3708, PE 3710, PE 4608, and PE 4708 are not in commercial production for geothermal piping systems. Including them in this code could influence a specifier to select one of those compounds which would not be commercially available, leading to potential confusion. The proposal simply removes the non-available piping materials.
This proposal would also allow the use of SDR 13.5 pipes produced using PE 4710 compounds because PE 4710 pipes have significantly greater resistance to slow crack growth and higher tensile strength than PE 3608 pipes. Therefore, the thicker wall in a SDR 11 pipe is not required for mechanical toughness when PE 4710 pipe is used. SDR 13.5 pipes produced of PE 4710 materials have higher thermal conductivity and flexibility than SDR 11 pipes, have additional advantages for installation and performance, and still meet the minimum pressure requirements.

On the other hand, PE 3608 pipes have lower tensile strength and a greater susceptibility to scratches and gouges that could lead to slow crack growth. So pipes produced using PE 3608 material should remain as the thicker-wall SDR 11 wall type.

Similar revisions have been agreed by the ANSI/CSA/IGSHPA C448 Piping Task Force for the next edition of that bi-national standard which is referenced within the USHGC. This proposal also helps to harmonize these two important codes.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Part I – General.

703.0 Design of Systems.

703.4 Underground Piping and Submerged Materials. (remaining text unchanged)

703.4.1 Polyethylene (PE). Polyethylene pipe or tubing shall be manufactured in accordance with the standards listed in Table 703.2. Pipe or tubing shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C). Polyethylene pipe or tubing shall be manufactured from a PE compound that has a pipe material designation code of PE 3608 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 AWWA C901. Polyethylene pipe or tubing shall have a minimum wall thickness in accordance with Table 703.4.1.

Exception: HDPE lateral piping with a minimum pressure rating of 100 psi (689 kPa) at 73°F (23°C) shall not be required to have a minimum wall thickness in accordance with Table 703.4.1.

TABLE 703.4.1

<table>
<thead>
<tr>
<th>PE PIPE MATERIAL</th>
<th>MINIMUM WALL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE 3608</td>
<td>SDR 11</td>
</tr>
<tr>
<td>PE 4710</td>
<td>SDR 13.5</td>
</tr>
</tbody>
</table>

Part II – Closed-Loop Systems.

710.0 General.

710.3 Borehole Piping and Tubing. Borehole piping or tubing for vertical and horizontally drilled closed-loop systems, shall have a minimum wall thickness in accordance with Table 703.4.1 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

COMMITTEE STATEMENT:
An exception is being added for HDPE lateral piping which does not require the same pressure ratings and wall thicknesses as the remaining underground system piping. This addition prevents overly stringent installation requirements and is beneficial to the code.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments
RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

TABLE 409.1
MATERIALS FOR HYDRONIC AND SOLAR THERMAL SYSTEM, PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
<th>FITTINGS</th>
</tr>
</thead>
</table>

(PORTION OF TABLE NOT SHOWN REMAINS 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 D2513-2020</td>
<td>Standard Specification for Polyethylene (PE)</td>
<td>Piping</td>
<td>Table 409.1</td>
</tr>
<tr>
<td></td>
<td>Gas Pressure Pipe, Tubing, and Fittings</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(PORTION OF TABLE NOT SHOWN REMAINS UNCHANGED)

SUBSTANTIATION:
This comment aligns with the removal of ASTM D2513 from Section 703.4.1 [Polyethylene (PE)]. As stated in the scope of ASTM D2513, “This specification covers requirements and test methods for material dimensions and tolerances, hydrostatic burst strength, chemical resistance, and rapid crack resistance of polyethylene pipe, tubing, and fittings for use in fuel gas pipelines for direct burial and re-liner applications.” Since the systems covered under Table 409.1 do not address fuel gas piping applications, the inclusion of the standard is not appropriate.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 082
USHGC 2024  Section: 705.6

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Revise text

Part I - General.

705.0 Valves.

705.6 Equipment and Appliances. Shutoff valves shall be installed on connections to mechanical equipment and appliances. This requirement shall not apply to components of a ground source loop system such as pumps, air separators, metering devices, and similar equipment.

SUBSTANTIATION:
Section 705.6 (Equipment and Appliances) is being updated to clarify that "mechanical equipment and appliances" do not refer to components of the ground source loop system but rather externally connected equipment. The current language enforces impractical and unnecessary requirements. For these reasons, the revision is needed.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language stating that "this requirement shall not apply to components of a ground source loop" is not technically justified. Furthermore, the term "similar equipment" is vague and unenforceable. For these reasons, the proposal is being rejected.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

Appendied Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: 203.0
SUBMITTER: Jazmin Curiel
Self

RECOMMENDATION:
Accept as Modified
Request to replace the code change proposal by this public comment.

203.0 - A -
Appliance. A device that utilizes fuel or electricity as an energy source to produce light, heat, power, refrigeration, or air conditioning. This definition also includes electric storage or tankless water heaters.

SUBSTANTIATION:
As defined in the Uniform Mechanical Code, appliances utilize “fuel or electricity as an energy source.” This additional language is needed for technical accuracy and improves the definition of “appliance.” The inclusion of “electric storage” and “tankless water heaters” further enhances the definition by including devices which fall under the category of appliance.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

203.0 - A -
Appliance. A device that utilizes fuel or electricity as an energy source to produce light, heat, power, refrigeration, or air conditioning. This definition also includes electric storage or tankless water heaters.

COMMITTEE STATEMENT:
Item #082 Public Comment 01 is being modified to remove the phrase “fuel or electricity” as there are other applicable energy sources that are not covered by this description. By removing this phrase, the definition for “appliance” is more inclusive of applicable devices used in the USHGC.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2
Code Year: 2024 USHGC  Section #: 705.6
SUBMITTER: Jazmin Curiel
Self
RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

705.0 Valves.

705.6 Equipment and Appliances. Shutoff valves shall be installed on connections to mechanical equipment and appliances. Exception: Shutoff valves are not required for the following ground source loop system components:
(1) Pumps,
(2) Air separators,
(3) Metering devices, and
(4) Other ground source loop systems components, as approved by the Authority Having Jurisdiction.

SUBSTANTIATION:
The original proposal has merit as there are components within the ground source loop system which would not require shutoff valves. Based on the committee's reasonings for rejecting the proposal, the recommendation has been modified to include an exception for ground source loop system components. This exception includes a list of typical components which do not require shutoff valves and allows for other components to fall under this exception where approved by the Authority Having Jurisdiction.
COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #082 Public Comment 02 is being rejected as the committee disagrees with the provided exception for shutoff valves. The existing language requiring shutoff valves on connections to mechanical equipment and appliances is needed to isolate system components.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 3
Code Year: 2024 USHGC  Section #: 209.0, 705.6  Item #: 082
SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group
Comment #: 3
RECOMMENDATION: Accept as Modified

Request to replace the code change proposal by this public comment.

705.0 Valves.

705.6 Equipment and Appliances. Shutoff valves shall be installed as a means of isolating connections to mechanical equipment and appliances. Exception: Shutoff valves shall not be required for individual geothermal ground-loops.

209.0 - G - Geothermal Ground-Loop. A conduit for a fluid, such as water or a water-based antifreeze solution, used to create a heat convection circuit that serves as a heat sink, source, or storage device. A single, closed continuous loop of pipe that is typically made of an approved substance such as polyethylene or polypropylene. The pipe is placed in the ground horizontally, vertically, or at an angle by either drilling or trenching. Ground loop(s) may be a single loop, or a collection of loops connected in series or parallel.

SUBSTANTIATION:
Based on the committee statement provided for rejection of Item #082 during the proposal stage, the Geothermal Energy Systems Task Group generated a recommendation which updates Section 705.6 (Equipment and Appliances) to clarify that shutoff valves serve “as a means of isolating mechanical equipment and appliances” and offers a new exception for individual geothermal ground loops. This exception avoids the use of ambiguous language and is furthermore supported by the proposed definition for “geothermal ground-loop.”

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

705.0 Valves.

705.6 Equipment and Appliances. Shutoff valves shall be installed as a means of isolating mechanical equipment and appliances. Exception: Shutoff valves shall not be required for individual geothermal ground-loops.

209.0 - G - Geothermal Ground-Loop. A conduit for a fluid, such as water or a water-based antifreeze solution, used to create a heat convection circuit that serves as a heat sink, source, or storage device. A single, closed continuous loop of pipe that is typically made of an approved substance such as polyethylene or polypropylene. The pipe is placed in the ground horizontally, vertically, or at an angle by either drilling or trenching. Ground loop(s) may be a single loop, or a collection of loops connected in series or parallel.
COMMITTEE STATEMENT:
In Item #082 Public Comment 03, the proposed definition for “geothermal ground-loop” is being modified to remove portions which introduce requirements as well as to ensure that the description is broad enough to avoid the exclusion of existing technology. The references to the approved piping materials and installation practices are not appropriate within the definition, and the term "heat convection" is being removed to avoid confusion between portions of the systems which utilize heat convection versus conduction.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 087
USHGC 2024  Section: 707.6

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Revise text

707.0 Installation Practices.

707.6 Ground Heat-Exchanger Installation Practices. A ground-heat exchanger system shall be installed as follows:

(1) - (5) (remaining text unchanged)

(6) Vertical and horizontal ground-heat exchangers shall maintain the following setbacks in accordance with the Authority Having Jurisdiction, or the following:

(a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Twenty-Fifty feet (6096 15 240 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c) Three-Five feet (941524 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 40050 feet (30 48915 240 mm) from a subsurface sewage leaching field.
(f) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.

(7) Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a single continuous operation from the bottom of the borehole by pumping through a tremie pipe.

(8) Horizontal ground heat exchangers shall maintain setbacks in accordance with the Authority Having Jurisdiction, or the following:

(a) Five feet (1524 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Ten feet (3048 mm) horizontally from a non-pressure treated sewer lateral into a building.
(c) Five feet (1524 mm) horizontally from buried utilities such as electrical gas or water.
(d) Ten Feet (3048 mm) from a water well.
(e) Ten feet (3048 mm) from a septic tank and 10 feet (3048 mm) from a subsurface leaching field.

SUBSTANTIATION:
The proposed revisions are needed to separate the requirements for vertical and horizontal setbacks. Vertical setbacks are being updated to correlate with current minimum required isolation distances from existing or potential sources of pollution. Such provisions enhance the requirements of Section 707.6 (Ground Heat-Exchanger Installation Practices) by providing clear and differentiated setbacks. Additionally, the new language prevents overly restrictive setbacks by requiring compliance with either the listed distances or those specified by the AHJ.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

707.0 Installation Practices.

707.6 Ground Heat-Exchanger Installation Practices. A ground-heat exchanger system shall be installed as follows:

(1) - (5) (remaining text unchanged)

(6) Vertical ground-heat exchangers shall maintain minimum setbacks in accordance with the Authority Having Jurisdiction, or the following, or the Authority Having Jurisdiction;
(a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Fifty feet (15 240 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c) Five feet (1524 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 50 feet (15 240 mm) from a subsurface sewage leaching field.
(f) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.

(7) Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

(8) Horizontal ground heat exchangers shall maintain minimum setbacks in accordance with the Authority Having Jurisdiction, or the following, or the Authority Having Jurisdiction:
(a) Five feet (1524 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Ten feet (3048 mm) horizontally from a non-pressure treated sewer lateral into a building.
(c) Five feet (1524 mm) horizontally from buried utilities such as electrical gas or water.
(d) Ten feet (3048 mm) from a water well.
(e) Ten feet (3048 mm) from a septic tank and 10 feet (3048 mm) from a subsurface leaching field.

COMMITTEE STATEMENT:
The modifications clarify that the Authority Having Jurisdiction has the final approval for setback distances and may choose to require the minimum setbacks as provided in this code. The term "treated" is also being replaced with "tested" for consistency and technical accuracy.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 707.6 - 707.7.2  Item #: 087
SUBMITTER: Jeff Persons  Comment #: 1
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

707.0 Installation Practices.

707.6 Ground Heat-Exchanger Installation Practices. A ground-heat exchanger system shall be installed as follows in accordance with the following:

(1) Outside piping or tubing located within 5 feet (1524 mm) of any wall or structure shall be continuously insulated with insulation that has a minimum R-5 value. Such pipe or tubing installed under the slab or basement floors shall be insulated within 5 feet (1524 mm) from the structure to the exterior point of exit from the slab.
(2) Freeze protection shall be provided where the design of the ground heat exchanger system would permit the heat-transfer medium to freeze.
(3) Horizontal piping shall be installed not less than 12 inches (305 mm) below the frost line.
(4) Submerged heat exchangers shall be protected from damage and shall be securely fastened to the bottom of the lake or pond, or other approved submerged structure.
(5) A minimum separation distance shall be maintained between the potable water intake and the submerged heat exchanger system in accordance with the Authority Having Jurisdiction.
(5) Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

707.7 Setbacks. In absence of minimum setbacks specified by the Authority Having Jurisdiction, minimum setbacks for vertical ground-heat exchanger systems shall be maintained in accordance with Section 707.7.1, and minimum setbacks for horizontal ground-heat exchanger systems shall be maintained in accordance with Section 707.7.2.

707.7.1 Vertical Systems. (6) Vertical ground-heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:
(a1) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b2) Fifty feet (15 240 mm) horizontally from a non-pressure tested sewer lateral into a building.
Item (3) Five feet (1524 mm) horizontally from buried utilities such as electrical, gas, or water.
Item (4) Fifty feet (15 240 mm) from a water well.
Item (5) Fifty feet (15 240 mm) from a septic tank and 50 feet (15 240 mm) from a subsurface sewage leaching field.
Item (6) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.
Item (7) Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

707.7.2 Horizontal Systems. (a) Horizontal ground heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:
(a) Five feet (1524 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Ten feet (3048 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c) Five feet (1524 mm) horizontally from buried utilities such as electrical gas or water.
(d) Ten Feet (3048 mm) from a water well.
(e) Ten feet (3048 mm) from a septic tank and 10 feet (3048 mm) from a subsurface leaching field.

SUBSTANTIATION:
Section 707.6 (Installation Practices) is being reorganized into multiple sections and subsections for needed clarity. Provisions pertaining to minimum setbacks are now covered under Section 707.7 (Setbacks) which addresses vertical ground heat exchangers in Section 707.7.1 (Vertical Systems) and horizontal ground heat exchangers in Section 707.7.2 (Horizontal Systems).

Item (5) was determined by the Geothermal Energy Systems Task Group to serve no purpose as it simply directs users of the code to the Authority Having Jurisdiction. Additionally, fluids used in submerged heat exchangers are required to be non-toxic and therefore offer no hazard to the potable water intake. Item (7) has been removed as it does not pertain to minimum setback requirements.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS:  AFFIRMATIVE: 16

PUBLIC COMMENT 2

Code Year: 2024 USHGC  Section #: 707.6 - 707.7.2  Item #: 087
SUBMITTER: Jeff Persons  Comment #: 2
Self

RECOMMENDATION:  Accept as Modified

Request to accept the code change proposal as modified by this public comment.

707.0 Installation Practices.

707.6 Ground Heat-Exchanger Installation Practices. A ground-heat exchanger system shall be installed as follows in accordance with the following:
(21) Freeze protection shall be provided where the design of the ground heat exchanger system would permit the heat-transfer medium to freeze.
(22) Where a ground-heat exchanger is designed to operate at sub-freezing temperatures, the outside piping or tubing located within 5 feet (1524 mm) of any wall or structure shall be continuously insulated with insulation that has a minimum R-5 value. Such pipe or tubing installed under the slab or basement floors shall be insulated within 5 feet (1524 mm) from the structure to the exterior or interior point of exit from the slab.
Exception: Cooling dominant ground heat exchangers shall not require insulation or freeze protection.
(3) Horizontal piping shall be installed not less than 12 inches (305 mm) below the frost line.
Exception: Where ground-heat exchangers are installed in areas of permafrost and operation is consistently at sub-freezing temperatures.
(4) Submerged heat exchangers shall be protected from damage and shall be securely fastened to the bottom of the lake or pond, or other approved submerged structure.
(5) A minimum separation distance shall be maintained between the potable water intake and the submerged heat exchanger system in accordance with the Authority Having Jurisdiction.
Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

**707.7 Setbacks.** In absence of minimum setbacks specified by the Authority Having Jurisdiction, minimum setbacks for vertical ground-heat exchanger systems shall be maintained in accordance with Section 707.7.1, and minimum setbacks for horizontal ground-heat exchanger systems shall be maintained in accordance with Section 707.7.2.

**707.7.1 Vertical Systems.** Vertical ground-heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:

- (a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
- (b) Fifty feet (15 240 mm) horizontally from a non-pressure tested sewer lateral into a building.
- (c) Five feet (1524 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 50 feet (15 240 mm) from a subsurface sewage leaching field.
- (f) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.

Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

**707.7.2 Horizontal Systems.** Horizontal ground heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:

- (a) Five feet (1524 mm) horizontally from a pressure-tested sewer lateral into a building.
- (b) Ten feet (3048 mm) horizontally from a non-pressure tested sewer lateral into a building.
- (c) Five feet (1524 mm) horizontally from buried utilities such as electrical gas or water.
- (d) Ten feet (3048 mm) from a water well.
- (e) Ten feet (3048 mm) from a septic tank and 10 feet (3048 mm) from a subsurface leaching field.

**SUBSTANTIATION:**

This public comment differs from the recommendation submitted on behalf of the Geothermal Energy Systems Task Group as follows:

Item (2) is being relocated to item (1) for better flow and organization of requirements. Item (2) includes additional language which addresses ground heat exchangers designed to operate at sub-freezing temperatures. This change avoids overly restrictive provisions which currently required all ground heat exchangers to be insulated regardless of design operation temperatures. Such requirement is unnecessary and should be dependent on geographical location along with other design parameters.

An exception for item (2) is being added for cooling dominant ground heat exchangers which do not require insulation or freeze protection. The purpose of insulation is to prevent frost heave at a building foundation created by freezing soil around the lines of a low temperature ground heat-exchanger. Cooling dominant applications which do not require the use of an antifreeze solution will never experience freezing temperatures. Therefore, insulation of these lines is unnecessary.

An exception for item (3) is necessary as there are locations where low-temperature ground heat-exchangers may be buried in permafrost conditions. In such cases, the 12 inch requirement is not appropriate.

Item (5) remains in the list of requirements since the Authority Having Jurisdiction should be the one to determine an appropriate separation distance between the potable water intake and submerged heat exchanger. Although the system fluids are non-toxic, potential contamination of any sort should be prevented.

**COMMITTEE ACTION:** REJECT

**COMMITTEE STATEMENT:**

Item #087 Public Comment 02 is being rejected in favor of the action taken on Item #087 Public Comment 01 as the committee prefers the recommendations generated by the Geothermal Energy Systems Task Group. In particular, Exception (3) is overly specific, and the committee does not agree with Exception (2) as there are cooling dominant ground-heat exchangers which require freeze protection.

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Request to accept the code change proposal as modified by this public comment.

209.0 - G — Ground-Heat Exchanger. An underground closed loop heat exchanger through which a heat transfer medium passes to and from a heat pump or other rated mechanical equipment. It includes the buried pipe and connecting main(s) up to and terminating with the building. The pipe or network of pipes that conveys a heat-transfer fluid, such as water or a water-based antifreeze solution, to conduct thermal energy to or from the earth which serves as a heat sink, source, or storage device. The pipe loop may be placed in the ground horizontally, vertically, or at an angle by either drilling or trenching. A ground-heat exchanger may be a single loop or a collection of loops connected in series or parallel.

SUBSTANTIATION:
These changes provide a better description of a ground-heat exchanger and the means by which it may be applied. This revised definition may be more suitable than the definition for "geothermal ground loop" submitted by the Geothermal Energy Systems Task Group. (See Item #082 Public Comment 3.)

This definition makes a correction regarding the means of heat transfer referenced as it should be "conduction" rather than "convection." Additionally, the submitted definition for "geothermal ground loop" lists approved piping materials which are best indicated in Section 703.2 (Piping and Tubing Material Standards), Table 703.2 (Plastic Ground Source Loop Piping), Section 703.3 (Fittings), and Table 703.3 (Ground Source Loop Pipe Fittings). Listing approved piping materials is not pertinent to the definition of a "ground heat-exchanger."

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Item #087 Public Comment 03 is being rejected as the committee prefers the existing definition for "ground-heat exchanger" which is more concise and technically accurate. The proposed revisions to the definition only add unnecessary complexity which may lead to misinterpretation and confusion.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 4

Request to accept the code change proposal as modified by this public comment.
Part III – Open-Loop Systems.

712.0 General.

712.4 Setbacks. Open-geothermal loops shall maintain separation between supply and discharge locations in accordance with the registered design professional and the following minimum setbacks or at distances specified by the Authority Having Jurisdiction:

1. Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
2. Twenty feet (6096 mm) horizontally from a non-pressure-tested sewer lateral into a building.
3. Three feet (914 mm) horizontally from buried utilities such as electrical, gas, or water.
4. Fifty feet (15 240 mm) from a water well.
5. Fifty feet (15 240 mm) from a septic tank and 100 feet (30 480 mm) from a subsurface sewage leaching field.
6. One hundred feet (30 480 mm) from a spring.

SUBSTANTIATION:
Minimum setbacks do not apply to open-loop heat exchange methods as they might to ground heat-exchangers. An open geothermal loop is not a ground heat-exchanger. By definition, a geothermal open loop derives its source of fluid heat exchange from surface water, ground water, or commercial/industrial process water/fluid. After its use the heat exchange fluid is discharged back to its source or to the environment. The distance/setback between the supply source and discharge are functions determined by the design professional and/or the Authority Having Jurisdiction.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Part III – Open-Loop Systems.

712.0 General.

712.4 Setbacks. Open-geothermal loops shall maintain separation between supply and discharge locations in accordance with the registered design professional and the Authority Having Jurisdiction.

COMMITTEE STATEMENT:
Item #087 Public Comment 04 is being modified to align with the scope of Part III (Open-Loop Systems) in Chapter 7. The revision to Section 712.4 (Setbacks) adds needed clarity and improves technical accuracy by replacing the phrase “open-geothermal loops” with “geothermal open-loop systems.”

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 088
USHGC 2024 Section: 707.13, 707.16.1, 707.17, 707.17.8

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Revise text

707.0 Installation Practices.

707.13 On-Site Storage - Exterior Piping Protection. Exterior piping shall be fitted with end caps and protected from freezing, UV radiation, corrosion, and degradation.

707.16 Horizontal Geothermal Piping - Materials and Methods. (remaining text unchanged)

707.16.1 Piping Materials. 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, and Section 715.3.

707.17 Trenches, Excavation, and Backfilled. (remaining text unchanged)

707.17.8 Tracer and Warning 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 a width of 6 inches (152 mm), or non-metallic warning tape used in conjunction with tracer wire that is listed and labeled in accordance complies with UL 2989. The tracer wire diameter shall be in accordance with the Authority Having Jurisdiction. Tracer and warning markings 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. Tracer wire shall be permitted to be installed at buried pipe grade.

(Section 715.3 is shown for information only)

715.3 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.

SUBSTANTIATION:
The title of Section 707.13 is being updated to represent the accompanying provision more appropriately.

Section 717.16.1 (Piping Materials) is being revised to include reference to Section 715.3 (DX Systems) as those provisions address copper pipe and tubing installed for DX systems.

Section 707.17.8 (Tracer and Warning Markings) is being modified to require compliance with the AHJ for tracer wire diameter sizing. Additionally, the new language permits the installation of tracer wire at buried pipe grade, or below grade and in direct contact with soil.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
707.0 Installation Practices.

707.13 **Exterior Piping Protection.** Exterior **Prior to system use and during construction,** piping shall be fitted with end caps and protected from freezing, UV radiation, corrosion, and degradation.

707.16 **Horizontal Geothermal Piping - Materials and Methods.** *(remaining text unchanged)*

707.16.1 **Piping Materials.** 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, and Section 715.3.

707.17 **Trenches, Excavation, and Backfill.** *(remaining text unchanged)*

707.17.8 **Tracer and Warning 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 a width of 6 inches (152 mm), or non-metallic warning tape used in conjunction with tracer wire that complies with UL 2989. **The tracer wire diameter shall be in accordance with the Authority Having Jurisdiction.**

Tracer and warning markings 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. Tracer wire shall be permitted to be installed at buried pipe grade.

**COMMITTEE STATEMENT:**
Section 707.13 is being updated to specify that piping should be protected during construction and prior to use. The previous language was vague and implied that all exterior piping, at all times, required end caps.

The requirements for tracer wire are ambiguous and serve no purpose. Additionally, tracer wire diameters are addressed by performance standards and verified through testing.

The Technical Committee also noted that additional clarity is recommended to define “buried pipe grade.”

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** **AFFIRMATIVE:** 16

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**Appended Comments**

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**PUBLIC COMMENT 1**

**Code Year:** 2024 USHGC  **Section #:** 707.17.8  
**SUBMITTER:** Jeff Persons  
Chair, USHGC Geothermal Energy Systems Task Group  
**Item #:** 088  
**Comment #:** 1

**RECOMMENDATION:**
Accept as Modified

Request to accept the code change proposal **as modified** by this public comment.

707.0 **Installation Practices.**

707.17 **Trenches, Excavation, and Backfill.** *(remaining text unchanged)*

707.17.8 **Tracer and Warning 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 a width of not less than 3 inches (76 mm) or 6 inches (152 mm) and with burial depths in accordance with the manufacturer’s specifications, or non-metallic warning tape used in conjunction with tracer wire that complies with UL 2989. **Tracer and warning markings 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.** Tracer wire shall be permitted to be installed at buried pipe grade.
SUBSTANTIATION:
Section 707.17.8 (Tracer and Warning Markings) is being updated to remove the current thickness requirement for metallic detectable tape, add new language requiring burial depths in accordance with the manufacturer's specifications, and remove the existing language pertaining to placement distances from horizontal piping of the heat exchanger.

The current minimum thickness of 11/64 inch is significantly larger than the standard thickness of metallic detectable buried pipe warning tape which is 0.005 inch, and the minimum width of 6 inches is overly restrictive and prevents the use of appropriate and available metallic detectable tape. Furthermore, the location requirement in relation to horizontal piping varies based on the selected tape and needs to be specified by the manufacturer.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 092
USHGC 2024  Section: 712.1

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

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. Outdoor piping, fittings, and accessories shall be in accordance with Section 703.2.

Components which come into contact with the system fluids and are installed in a geothermal open-loop system shall be constructed of corrosion resistant materials or in accordance with the AHJ.

SUBSTANTIATION:
Since open-loop geothermal components are continuously exposed to groundwater or surface water, corrosion prevention substantially influences the design of geothermal systems.

The water quality of these sources varies and can in some cases be inferior causing scaling and corrosion. For these reasons, components of the system which come into contact with the source fluid need to be constructed of corrosion resistant materials.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

EXPLANATION OF AFFIRMATIVE:

MACNEVIN: This section probably should also require that these components comply with NSF/ANSI/CAN 61, unless that is covered in a related section of this chapter. Also, does "corrosion resistant" need any type of clarification? Address in public comment.

MACK: NSF/ANSI/CAN 61 may be overly restrictive if required. NSF 372 may be a better option.
PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 712.1, Table 901.1  Item #: 092

SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

712.0 General.

712.1 Applicability. Part III of this chapter shall apply to geothermal open-loop energy systems such as, but not limited to, building systems coupled with a groundwater (well) or surface water open-loop system 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. Outdoor piping, fittings, and accessories shall be in accordance with Section 703.2. Components which come into contact with the system fluids and are installed in a geothermal open-loop system shall be constructed of corrosion resistant materials or in accordance with the Authority Having Jurisdiction. Materials which come into contact with potable water shall comply with NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
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<td>Miscellaneous</td>
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<td>NSF/ANSI/CAN 372-2022</td>
<td>Drinking Water System Components - Lead Content</td>
<td>Miscellaneous</td>
<td>712.1</td>
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(portion of table not shown remains unchanged)

Note: NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372 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 712.1 (Applicability) is being updated to better align with the intent of Part III (Open-Loop Systems). In particular, minor revisions to phrasing have been made to specify that the sections pertain to “geothermal open-loop systems.” Additionally, reference to Section 703.2 (Piping and Tubing Material Standards) has been removed as such provisions currently exist under “General” requirements which apply to all other portions or parts of Chapter 7. Therefore, such reference is redundant and unnecessary.

The last paragraph of the section has also been revised to remove language which implies that some open-loop systems may be constructed without corrosion resistant materials, and two industry standards have been included to address materials which come into contact with potable water. Both NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372 offer needed protection for potable water sources, such as groundwater wells, that may be used in open-loop systems. As depicted below, these standards address potential contaminants and impurities that negatively impact water quality.

NSF/ANSI/CAN 61 establishes minimum health effects and requirements for the chemical contaminants and impurities that are indirectly imparted to drinking water from products, components, and materials used in drinking water systems.

NSF/ANSI/CAN 372 establishes procedures for determination of lead content based on wetted surface areas of products.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
PUBLIC COMMENT 2

Code Year: 2024 USHGC  Section #: 710.1, 712.1, Figure 710.1(1), Figure 710.1(2), Figure 712.1(1), Figure 712.1(2)

SUBMITTER: Lee Stevens
LH Stevens Construction LLC

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

710.0 General.

710.1 Applicability. Part II of this chapter shall apply to closed-loop geothermal energy systems such as, but not limited to, building systems coupled with a closed-loop system using water-based fluid as a heat transfer medium systems coupled to a ground loop heat exchanger, or a heat exchanger submerged in a surface body of water. (See Figure 710.1(1) for a simplified schematic of a closed-loop geothermal system coupled to a ground loop heat exchanger, See Figure 710.1(2) for a simplified schematic of a closed-loop geothermal system coupled to a heat exchanger submerged in a surface body of water.)

Notes:
1 This schematic does not include all system components, and configurations may vary based on design.
2 The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the closed-loop geothermal system loop.
FIGURE 710.1(2)\textsuperscript{1,2}
CLOSED-LOOP SYSTEM COUPLED TO A HEAT EXCHANGER SUBMERGED IN A SURFACE BODY OF WATER
(SIMPLIFIED SCHEMATIC)

Notes:
\textsuperscript{1} This schematic does not include all system components, and configurations may vary based on design.
\textsuperscript{2} The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the closed-loop geothermal system loop.

Part III – Open-Loop Systems.

712.0 General.
712.1 Applicability. Part III of this chapter shall apply to open-loop geothermal energy systems such as, but not limited to, building systems coupled to a source of 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. Outdoor piping, fittings, and accessories shall be in accordance with Section 703.2.

Components which come into contact with the system fluids and are installed in a geothermal open-loop system shall be constructed of corrosion resistant materials or in accordance with the Authority Having Jurisdiction. (See Figure 712.1(1) for a simplified schematic of an open-loop geothermal system utilizing subsurface water. See Figure 712.1(2) for a simplified schematic of an open-loop geothermal system utilizing surface water.)
Notes:
1. This schematic does not include all system components, and configurations may vary based on design.
2. The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the open-loop geothermal system loop.
SUBSTANTIATION:
Taken together, Section 710.1 (Applicability) and Section 712.1 (Applicability) are used to differentiate and then regulate the installation of closed and open loop geo-sourced systems. As written, the applicability seems to be describing the building space heating or cooling system, presumably a closed loop hydronic system in its own right. The proposed language is to clarify that these two sections relate specifically to only the geo-source loops, and are differentiated further by specifying either open or closed loops. In the broadest terms “geothermal energy system” may be construed to be the total set of equipment and various thermal energy transfer loops, as shown in the submitted figures. However, the heat pump and “downstream” hydronic loop are outside the intent and scope of these two sections, and are regulated under the provisions of other sections, such as Chapter 4.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

710.0 General.
710.1 Applicability. Part II of this chapter shall apply to closed-loop geothermal systems such as, but not limited to, systems coupled to a ground loop heat exchanger, or a heat exchanger submerged in a surface body of water. [See Figure 710.1(1) for an example of a simplified schematic of a closed-loop geothermal system coupled to a ground loop heat exchanger. See Figure 710.1(2) for an example of a simplified schematic of a closed-loop geothermal system coupled to a heat exchanger submerged in a surface body of water.]

FIGURE 710.1(1)¹,²
EXAMPLE OF A CLOSED-LOOP SYSTEM COUPLED TO A GROUND LOOP HEAT EXCHANGER (SIMPLIFIED SCHEMATIC)

Notes:
¹ This schematic does not include all system components, and configurations may vary based on design.
² The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the closed-loop geothermal system loop.
FIGURE 710.1(2)\(^1, 2\)

**EXAMPLE OF A CLOSED-LOOP SYSTEM COUPLED TO A HEAT EXCHANGER SUBMERGED IN A SURFACE IN A SURFACE BODY OF WATER**

**(SIMPLIFIED SCHEMATIC)**

Notes:

1. This schematic does not include all system components, and configurations may vary based on design.
2. The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the closed-loop geothermal system loop.

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**Part III – Open-Loop Systems.**

**712.0 General.**

**712.1 Applicability.** Part III of this chapter shall apply to open-loop geothermal systems such as, but not limited to, systems coupled to a source of groundwater (well) or surface water. 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. Outdoor piping, fittings, and accessories shall be in accordance with Section 703.2.

Components which come into contact with the system fluids and are installed in a geothermal open-loop system shall be constructed of corrosion resistant materials or in accordance with the Authority Having Jurisdiction. Materials which come into contact with potable water shall comply with NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372. [See Figure 712.1(1) for an example of a simplified schematic of an open-loop geothermal system utilizing subsurface water. See Figure 712.1(2) for an example of a simplified schematic of an open-loop geothermal system utilizing surface water.]
FIGURE 712.1(1)\textsuperscript{1, 2}
EXAMPLE OF AN OPEN-LOOP SYSTEM UTILIZING SUBSURFACE WATER
(SIMPLIFIED SCHEMATIC)

Notes:
\textsuperscript{1} This schematic does not include all system components, and configurations may vary based on design.
\textsuperscript{2} The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the open-loop geothermal system loop.

FIGURE 712.1(2)\textsuperscript{1, 2}
EXAMPLE OF AN OPEN-LOOP SYSTEM UTILIZING SURFACE WATER
(SIMPLIFIED SCHEMATIC)

Notes:
\textsuperscript{1} This schematic does not include all system components, and configurations may vary based on design.
\textsuperscript{2} The heat pump refrigerant loop and the outgoing building hydronic loop are not considered part of the open-loop geothermal system loop.
### TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF/ANSI/CAN 61-2019/2022</td>
<td>Drinking Water System Components - Health Effects</td>
<td>Miscellaneous</td>
<td>501.5.4. 712.1</td>
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<tr>
<td>NSF/ANSI/CAN 372-2022</td>
<td>Drinking Water System Components - Lead Content</td>
<td>Miscellaneous</td>
<td>712.1</td>
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</table>

(portion of table not shown remains unchanged)

**COMMITTEE STATEMENT:**

Item #092 Public Comment 02 is being amended to clarify that Figure 710.1(1), Figure 710.1(2), Figure 712.1(1), and Figure 712.1(2) are all “examples” of simplified schematics. Such distinction is necessary since these figures do not encompass all possible configurations. For this reason, the phrase "example of" has been added to text which references the figures as well as the figure titles. These revisions align with the committee's actions on Item #035 Public Comment 01.

Additionally, the committee incorporated the following recommendations from Item #092 Public Comment 01: reference to NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372 for materials which come into contact with potable water; removal of language pertaining to outdoor piping, fittings, and accessories; and updates to require all components within a open-loop geothermal system to be constructed of corrosion resistant materials.

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 094
USHGC 2024  Section: 203.0, 208.0, 716.0 - 716.2

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Add new text

Part V – District Ambient Temperature Loop (ATL) Geothermal.

716.0 Ambient Temperature Loop (ATL) Distributed Energy Systems.

716.1 General. An ambient temperature loop (ATL) distributed energy system shall be installed in accordance with Section 716.2 through Section 716.6.3, and Section 717.0. ATL systems shall comply with Part I through Part IV of this chapter, as applicable.

716.1.1 Fourth Generation (4G) System Configuration. A fourth-generation system configuration shall be a district geothermal energy system distributing hot water, cold water, or both to the conditioned space or building for a specific use. Where a geothermal energy source is used, such systems shall comply with Part I through Part IV of this chapter and Chapter 4.

716.1.2 Fifth Generation (5G) System Configurations. An advanced ambient temperature (ATL) system or fifth generation (5G) ATL system shall also be capable of interacting with the electric utility system as well as other utility systems and systems components. System components shall include, but not be limited to, the following:
1. Thermally diverse buildings with independent hydronic systems.
2. Circulation loop.
3. Global control system.
4. Segment isolation capability.

Note: System components may include, but are not limited to, the following:
1. Electric grid-interactive enabled buildings
2. Hybrid components
3. Other renewable systems

716.2 Permitting. Permits required for the installation and application of an ATL distributed energy system shall be obtained as required by the Authority Having Jurisdiction.

203.0 – A –
Ambient Temperature Loop (ATL). A closed loop piping system with central pumping that includes various heat sources and heat sinks to hold the loop fluid temperature near the long term average ambient air temperature for a given geographical location. The sources/sinks can be passive (e.g., a ground loop, a body of water, sewer effluent) or active (e.g., a cooling tower) and further can include opportunistic, or unique locally available waste or by-product heat sources (e.g., data center, industrial process). The closed loop piping system typically controls or engages these sources/sinks to maintain the loop temperature to meet the seasonal requirements as well as specific building needs.

208.0 – F –
Fifth Generation (5G) System Configurations. An advanced ambient temperature (ATL) system that distributes near ambient temperature water among and between end use buildings that are equipped with water-source heat pumps or other water source HVAC equipment. Such systems stand in contrast to fourth generation (4G) systems that distribute hot water or chilled water to buildings to serve facility loads.
Fourth Generation (4G) System Configurations. A district geothermal energy system that distributes dedicated hot water and chilled water for direct use in the conditioned space.
SUBSTANTIATION:
Part V (District Ambient Temperature Loop) is being proposed in response to the attention drawn to ambient temperature loop district systems. Many states have implemented carbon reduction plans and non-combustion alternatives, and district ambient temperature loops coincide with these initiatives. Such systems lack installation requirements throughout the code and should therefore be provided.

Ambient temperature loops are high efficiency systems that recover wasted energy that is normally rejected to the atmosphere. The proposed provisions in Section 716.1.1 and Section 716.1.2 address the general requirements for fourth and fifth generation systems; along with permitting requirements.

The definitions for “fourth generation (4G) system configuration” and “fifth generation (5G) system configuration” are included as such systems are not currently defined and are not commonly known. A definition for “ambient temperature loop (ATL)” was also added to support the proposed code changes pertaining to these systems. The provided language appropriately defines ATL systems and informs users of the code that ATLs are closed-loop piping systems which include various heat sources and heat sinks.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The Technical Committee has requested that additional time be provided to review the proposed requirements for district systems and ambient temperature loops. The Technical Committee will submit all comments and concerns via their letter ballots for Item #073, Item #074, Item #094, Item #095, Item #096, Item #097, and Item #098. It is recommended that the Geothermal Energy Systems Task Group reconvene to address all submitted feedback and resubmit proposals via public comments.

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS:  AFFIRMATIVE: 16

EXPLANATION OF AFFIRMATIVE:
SMITH: This item is part of a multiple submission to update Chapter 7 and should not have been rejected but may need to be modified by the subcommittee and resubmitted in public comment.

Appended Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: 716.0 - 716.2, Figure 716.1  Item #: 094
SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group
Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to replace the code change proposal by this public comment.

Part V – Ambient Temperature Loops (ATL) Geothermal.

716.0 Ambient Temperature Loop (ATL) Distributed Energy Systems.
716.1 General. An ambient temperature loop (ATL) distributed energy system shall be installed in accordance with Section 716.2 through Section 716.6.3, and Section 717.0. ATL systems shall comply with Part I through Part IV of this chapter, as applicable. (See Figure 716.1 for a schematic of a geothermal system utilizing an ambient temperature loop.)

716.1.1 Fourth Generation (4G) System Configuration. A fourth-generation system configuration shall be a district geothermal energy system distributing hot water, cold water, or both to the conditioned space or building for a specific use. Where a geothermal energy source is used, such systems shall comply with Part I through Part IV of this chapter and Chapter 4.
716.1.2 Fifth Generation (5G) System Configurations. An advanced ambient temperature loop (ATL) System or fifth generation (5G) ATL system shall also be capable of interacting with the electric utility system as well as other utility systems and systems components.

System components shall include, but not be limited to, the following:
(1) Thermally diverse buildings with independent hydronic systems.
(2) Circulation loop.
(3) Global control system.
(4) Segment isolation capability.

Note: System components may include, but are not limited to, the following:
(1) Electric grid-interactive enabled buildings
(2) Hybrid components
(3) Other renewable systems

716.2 Permitting. Permits required for the installation and application of an ATL distributed energy system shall be obtained as required by the Authority Having Jurisdiction.

FIGURE 716.1
GEOTHERMAL SYSTEM SCHEMATIC: EXAMPLE OF AN AMBIENT TEMPERATURE LOOP (ATL)

* Equipment arrangements and configurations may vary.
SUBSTANTIATION:
Part V (Ambient Temperature Loops (ATL) Geothermal) is being proposed in response to the attention drawn to ambient temperature loop systems. Many states have implemented carbon reduction plans and non-combustion alternatives, and district ambient temperature loops coincide with these initiatives. Such systems lack installation requirements throughout the code and should therefore be provided.

Ambient temperature loops are high efficiency systems that recover wasted energy that is normally rejected to the atmosphere. The proposed provisions in Section 716.1.1 and Section 716.1.2 address the general requirements for fourth and fifth generation systems.

Figure 716.1 is being added as it supports the new revisions to Chapter 7 pertaining to ambient loops. Included within the schematic is an ambient temperature loop connected to solar thermal collectors, a closed-loop heat exchanger, a surface water heat exchanger, multiple heat pumps, and a closed-circuit cooling tower. Since wastewater sludge is high in organic content and offers the potential for energy recovery via thermochemical conversion technologies, a wastewater energy recovery system has been added to the schematic.

The provided schematic offers a simplified and clear visual of an ambient temperature loop system and further supports the revised applicability as shown in the previous item submitted by this Task Group. For these reasons, the figure is beneficial to the code and should be included in Chapter 7.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16

PUBLIC COMMENT 2
Code Year: 2024 USHGC  Section #: 210.0
SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group
RECOMMENDATION: Accept as Modified

Request to replace the code change proposal by this public comment.

210.0 - H -
Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

Hydronic System, Ambient Temperature Loop (ATL). A closed loop piping system with central pumping that includes various heat sources and heat sinks to hold the loop fluid temperature near the long term average ambient air temperature for a given geographical location. The sources/sinks can be passive (e.g., a ground loop, a body of water, sewer effluent) or active (e.g., a cooling tower) and further can include opportunistic, or unique locally available waste or by-product heat sources (e.g., data center, industrial process). The closed loop piping system typically controls or engages these sources/sinks to maintain the loop temperature to meet the seasonal requirements as well as specific building needs.

Hydronic System, Fifth Generation (5G) System Configurations. An advanced ambient temperature (ATL) system that distributes near ambient temperature water among and between end use buildings that are equipped with water-source heat pumps or other water source HVAC equipment. Such systems stand in contrast to fourth generation (4G) systems that distribute hot water or chilled water to buildings to serve facility loads.

Hydronic System, Fourth Generation (4G) System Configurations. A district geothermal energy system that distributes dedicated hot water and chilled water for direct use in the conditioned space.
SUBSTANTIATION:
The definitions for “fourth generation (4G) system configuration” and “fifth generation (5G) system configuration” are included as such systems are not currently defined and are not commonly known. A definition for “ambient temperature loop (ATL)” was also added to support the proposed code changes pertaining to these systems. The provided language appropriately defines ATL systems and informs users of the code that ATLs are closed-loop piping systems which include various heat sources and heat sinks.

As requested in the other recommendations generated by the Geothermal Energy Systems Task Group, these definitions are being located under the main definition for “hydronic system.”

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
SUBMITTER: Jeff Persons  
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:  
Add new text

716.3 Ambient Loop Temperature Range. The operating loop temperature range of an ambient temperature loop (ATL) system shall be not less than the freezing point of the circulating fluid and not more than the maximum temperature, as required by the manufacturer’s installation instructions for the attached heat pump equipment in accordance with Section 716.3.1 and Section 716.3.2. The ATL system shall use treated water as the heat transfer medium.

716.3.1 ATL Operating Temperature. For equipment listed to AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2, the controlled temperature range of the ambient closed-loop shall be not less than 7°F (4°C) above the freezing point of the transport fluid and 10°F (6°C) below the (collective) heat pump lowest maximum inlet supply temperature as recommended by the manufacturer’s instructions.

Exception: Equipment that is not listed to AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2, the controlled temperature range of the ambient closed loop shall be in accordance with Section 716.3.2 for minimum and maximum temperatures.

716.3.2 ATL Operating Temperature Range for Mixed Equipment Certifications. The source inlet temperature range of any attached equipment shall govern the design operating temperature range. Such equipment shall be identified in the design documentation. In any case, the most restrictive minimum and maximum inlet supply temperatures, as recommended by the manufacturer’s instructions, shall determine the system operating temperature range.

716.4 Shutoff Valve. An automatic shutoff valve shall be provided for each individual building or facility transferring energy to or from an ATL distribution system. The automatic shutoff valve shall automatically shutoff upon operating command.

716.4.1 Shutoff Valve Operation. The operation of the automatic shutoff valve shall be in accordance with the system operating procedures. Where the operation of a shutoff valve was due to an emergency response, an auxiliary heating or cooling methodology shall be provided in accordance with Section 717.1.2.

716.5 Bypass. The ATL distributed energy system shall be provided with bypass path(s) to reroute the circulating fluid when necessary.

Note: AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2 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:  
Section 716.3 through Section 716.5 further address the characteristics and required components of an ATL system. In particular, Section 716.3.1 is necessary as it provides the required controlled temperature range for ambient temperature loops where heat pumps are listed to AHRI/ASHRAE/ISO 13256-1 or AHRI/ASHRAE/ISO 13256-2.

For systems incorporating heat pumps not listed to those standards, Section 716.3.2 addresses the controlled temperature range in a conservative manner by requiring the most restrictive minimum and maximum supply temperatures recommended by the manufacturer.
Section 716.4 is important as it requires automatic shutoff valves for each building or facility connected to the ATL system. The proposed language in Section 716.4.1 ensures automatic emergency response via these shutoff valves and also requires available back-up heating or cooling methods.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The Technical Committee has requested that additional time be provided to review the proposed requirements for district systems and ambient temperature loops. The Technical Committee will submit all comments and concerns via their letter ballots for Item #073, Item #074, Item #094, Item #095, Item #096, Item #097, and Item #098. It is recommended that the Geothermal Energy Systems Task Group reconvene to address all submitted feedback and resubmit proposals via public comments.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

EXPLANATION OF AFFIRMATIVE:

SMITH: This item is part of a multiple submission to update Chapter 7 and should not have been rejected but may need to be modified by the subcommittee and resubmitted in public comment.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 716.3 - 716.5  Item #: 095
SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group  Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as submitted by this public comment.

SUBSTANTIATION:
Section 716.3 through Section 716.5 further address the characteristics and required components of an ATL system. In particular, Section 716.3.1 is necessary as it provides the required controlled temperature range for ambient temperature loops where heat pumps are listed to AHRI/ASHRAE/ISO 13256-1 or AHRI/ASHRAE/ISO 13256-2.

For systems incorporating heat pumps not listed to those standards, Section 716.3.2 addresses the controlled temperature range in a conservative manner by requiring the most restrictive minimum and maximum supply temperatures recommended by the manufacturer.

Section 716.4 is important as it requires automatic shutoff valves for each building or facility connected to the ATL system. The proposed language in Section 716.4.1 ensures automatic emergency response via these shutoff valves and also requires available back-up heating or cooling methods.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
716.6 Metering. Where meters are required by the system design, meter(s) shall be located as specified by the manufacturer on each consumptive or supply source, and the range of the metering shall be appropriate to the thermal properties and flow rate(s) of the transport fluid.

716.6.1 Sub-Metering System Specification. The entire energy measurement system shall be provided with a sub-metering system. The metering system shall be calibrated and shall consist of a flow meter, temperature sensors, temperature thermowells, or other required mechanical installation metering. The sub-meter traceable calibration shall comply with a National Institute of Standards Technology (NIST) traceable calibration program or in accordance with the Authority Having Jurisdiction and shall be provided with an ATL distributed energy system.

716.6.2 BTU/Thermal Meters. Where used, the Btu/thermal meter shall be bidirectional and shall provide the following information via digital or analog display:

(1) LCD, and via serial network communications.
(2) Total energy, Btu (kWh).
(3) Energy rate, Btu/h (kW).
(4) Total flow, gal (L).
(5) Flow rate, gpm (L/s).
(6) Supply temperature, °F (°C).
(7) Return temperature, °F (°C).

Each Btu/thermal meter shall be factory programmed for its specific application and shall be re-programmable to adjust for specific site conditions.

716.6.3 Flow Meter. Where used, the flow meter shall be provided with the following information via digital or analog display:

(1) LCD, and via serial network communications.
(2) Instantaneous fluid rate, gpm (L/s).
(3) Cumulative fluid flow volume, gal (L).

SUBSTANTIATION:
Section 716.6 through Section 716.6.3 are intended to require energy movement data with sufficient accuracy to both measure system performance and individual asset performance. The respective metering methods also provide the basis for a use or energy transfer custody platform. In addition, this section is recognizing that there are multiple ways to effectively measure energy transfer.

Section 716.6.1 calls out the National Institute of Standards Technology (NIST) traceable calibration program for sub-meters to provide users of the code with the most appropriate method of calibration. To prevent overly restrictive requirements, the proposed language also leaves the calibration program selection up to the Authority Having Jurisdiction. Such calibration is necessary since the entire energy measurement system is provided with the sub-metering system which relies on inputs from flow meters, temperature sensors, thermowells, etc.
Section 716.6.2 then addresses thermal metering which allows for the measurement of energy used to heat and cool individual units. It is the most accurate method for monitoring heating and cooling consumption. For these reasons, the proposed requirements for metering are necessary and further support the remaining items submitted pertaining to ATLs in Chapter 7.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The Technical Committee has requested that additional time be provided to review the proposed requirements for district systems and ambient temperature loops. The Technical Committee will submit all comments and concerns via their letter ballots for Item #073, Item #074, Item #094, Item #095, Item #096, Item #097, and Item #098. It is recommended that the Geothermal Energy Systems Task Group reconvene to address all submitted feedback and resubmit proposals via public comments.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

EXPLANATION OF AFFIRMATIVE:

SMITH: This item is part of a multiple submission to update Chapter 7 and should not have been rejected but may need to be modified by the subcommittee and resubmitted in public comment.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 716.6 - 716.6.3
SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as submitted by this public comment.

SUBSTANTIATION:
Section 716.6 through Section 716.6.3 are intended to require energy movement data with sufficient accuracy to both measure system performance and individual asset performance. The respective metering methods also provide the basis for a use or energy transfer custody platform. In addition, this section is recognizing that there are multiple ways to effectively measure energy transfer.

Section 716.6.1 calls out the National Institute of Standards Technology (NIST) traceable calibration program for sub-meters to provide users of the code with the most appropriate method of calibration. To prevent overly restrictive requirements, the proposed language also leaves the calibration program selection up to the Authority Having Jurisdiction. Such calibration is necessary since the entire energy measurement system is provided with the sub-metering system which relies on inputs from flow meters, temperature sensors, thermowells, etc.

Section 716.6.2 then addresses thermal metering which allows for the measurement of energy used to heat and cool individual units. It is the most accurate method for monitoring heating and cooling consumption. For these reasons, the proposed requirements for metering are necessary and further support the remaining items submitted pertaining to ATLs in Chapter 7.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 097
USHGC 2024  Section: 221.0, 222.0, 717.0 - 717.1.2

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Add new text

717.0 ATL Distributed Energy Systems Design Requirements.

717.1 Thermal Resources. The ambient temperature loop shall be permitted to connect to a thermal resource(s). Such resources may be an alternative energy source and sink, such as but not limited to, solar photovoltaic (PV), solar thermal, combined heat power (CHP), and phase change thermal storage. These systems shall be installed and comply with the respective system requirements. ATL distributed energy systems coupled with solar thermal systems shall comply with this code or equivalent. ATL systems coupled with a solar PV system shall comply with this code or NFPA 70, or equivalent. These systems shall optimize the use of the equipment and energy based on the system design intent.

717.1.1 System Performance. The System Coefficient of Performance (SCOP) shall account for the net COP of each individual component(s) in the district. The SCOP shall be provided by the designer and included in the system design documents.

717.1.2 Emergency Response. An auxiliary heating or cooling methodology shall be provided with the ATL controls and shall be adequate to provide temporary service in the absence of an ATL energy transfer. Emergency source/sink measures such as, but not limited to, control subroutines that move energy between spaces in the building, the use of locally connected ground-source assets, combined heat and power (CHP), conventional equipment, and other renewable systems shall be permitted to be used.

221.0 – S –
System Coefficient of Performance (SCOP). A ratio of the total system energy moved divided by the total system purchased energy.

222.0 – T –
Thermal Resources. A source for heating and a sink for cooling. There are two types of sources:
(1) Conventional-type: such systems are known as geothermal energy systems, including air-source resources and ground-source resources.
(2) Opportunistic-type: such systems use water-source resources (e.g., oceans, rivers, raw sewage pipes, treated sewage outfall, potable water pipes, etc.), process byproduct heat resources (e.g., data center cooling process reject heat, industrial process reject heat, etc.), and other resources.

Note: NFPA 70 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:
By definition, the ATL will use multiple types of sources and sinks along with multiple heat transfer devices. This section is intended to demonstrate different assets that are commonly used in conjunction with the ATL to meet specific system needs and ensure that temporary service reductions are anticipated in the design process.
A standard metric, system coefficient of performance (SCOP) must be used to evaluate the ATL design intent performance to include transport energy and wasted energy recovered. Sources and sinks are usually spread across the ATL system, GeoMicroDistrict, or thermal highway and provisions should be made to handle temporary reduction or loss of services utilizing assets currently connected to the ATL.

Section 717.1 (Thermal Resources) is not intended to include a redundant system but rather to address the use of existing or attached thermal resources. Furthermore, definitions for "thermal resource" and "system coefficient of performance (SCOP)" are being added as they are not currently defined in the code and such inclusion will assist the end user with interpreting and applying the listed provisions.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposal is being rejected as there is concern that coupling ALT systems with solar PV systems or solar thermal systems is impractical. Furthermore, the provisions may conflict with other codes, such as the fire code.

As previously noted, the Technical Committee has requested that additional time be provided to review the proposed requirements for district systems and ambient temperature loops. The Technical Committee will submit all comments and concerns via their letter ballots for Item #073, Item #074, Item #094, Item #095, Item #096, Item #097, and Item #098. It is recommended that the Geothermal Energy Systems Task Group reconvene to address all submitted feedback and resubmit proposals via public comments.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 15  NEGATIVE: 1

EXPLANATION OF AFFIRMATIVE:

FECTEAU: How would this system be coupled with a PV system? If such a system exists, compliance with all applicable codes and standards should be mandatory, not the ability to choose only certain codes and standards. If this is placed between the Solar PV modules and the roof, this will affect the listing and fire rating of the solar PV system. Thermal collector listing would also be in question as the two systems have not been evaluated together. If the intent is that the PV system only provide the power to the ATL, then this will need to be written to reflect that.

SMITH: This item is part of a multiple submission to update Chapter 7 and should not have been rejected but may need to be modified by the subcommittee and resubmitted in public comment.

EXPLANATION OF NEGATIVE:

RODRIGUEZ: There is no consideration for the listing or manufacturer instructions to connect the ATL to other systems.

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Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: 218.0, 221.0, 222.0, 717.0 - 717.1.2  Item #: 097  Comment #: 1

SUBMITTER: Jeff Persons  Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION: Accept as Modified
Request to replace the code change proposal by this public comment.

717.0 ATL Distributed Energy Systems Design Requirements.

717.1 Thermal Resources. The ambient temperature loop (ATL) shall be permitted to connect to a thermal resource(s). Such resources may be an alternative energy source and sink, such as but not limited to, solar photovoltaic (PV), solar thermal, combined heat power (CHP), and phase change thermal storage. These systems shall be installed and comply with the respective system requirements. ATL distributed energy systems coupled with solar thermal systems shall comply with this code or equivalent. ATL systems coupled with a solar photovoltaic (PV) or a photovoltaic thermal system (PVT) shall comply with this code or NFPA 70, or equivalent. These systems shall optimize the use of the equipment and energy based on the system design intent.

717.1.1 System Performance. The System Coefficient of Performance (SCOP) shall account for the net COP of each individual component(s) in the district. The SCOP shall be provided by the designer and included in the system design documents.

717.1.2 Emergency Response. An auxiliary heating or cooling methodology shall be provided with the ATL controls and shall be adequate to provide temporary service in the absence of an ATL energy transfer. Emergency source/sink measures such as, but not limited to, control subroutines that move energy between spaces in the building, the use of locally connected ground-source assets, combined heat and power (CHP), conventional equipment, and other renewable systems shall be permitted to be used.

218.0 - P - Photovoltaic Thermal System (PVT). A hybrid system which incorporates a heating or cooling solar thermal system in combination with a solar photovoltaic system to generate both electrical and thermal energy. These systems are designed to improve system efficiency and simultaneously produce or reject thermal energy.

221.0 - S - System Coefficient of Performance (SCOP). A ratio of the total system energy moved to the total system purchased energy.

222.0 - T - Thermal Resources. A source for heating and a sink for cooling. There are two types of sources:
(1) Conventional-type: such systems are known as geothermal energy systems, including air-source resources and ground-source resources.
(2) Opportunistic-type: such systems use water-source resources (e.g., oceans, rivers, raw sewage pipes, treated sewage outfall, potable water pipes, etc.), process byproduct heat resources (e.g., data center cooling process reject heat, industrial process reject heat, etc.), and other resources.

Note: NFPA 70 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:
By definition, the ATL will use multiple types of sources and sinks along with multiple heat transfer devices. This section is intended to demonstrate different assets that are commonly used in conjunction with the ATL to meet specific system needs and ensure that temporary service reductions are anticipated in the design process.

A standard metric, system coefficient of performance (SCOP) must be used to evaluate the ATL design intent performance to include transport energy and wasted energy recovered. Sources and sinks are usually spread across the ATL system, GeoMicroDistrict, or thermal highway and provisions should be made to handle temporary reduction or loss of services utilizing assets currently connected to the ATL.

Section 717.1 (Thermal Resources) is not intended to include a redundant system but rather to address the use of existing or attached thermal resources. Resulting from additional review by the Geothermal Energy Systems Task Group, both solar photovoltaic (PV) and photovoltaic thermal systems (PVT) have been included as potential renewable energy sources that ATLs may be coupled with. Such systems are used in the industry to improve thermal and electrical efficiency and should also be listed with this section. For added clarity, a definition for "photovoltaic thermal system (PVT)" has been proposed for insertion into Chapter 2 (Definitions).

Furthermore, definitions for "thermal resource" and "system coefficient of performance (SCOP)" are being added as they are not currently defined in the code and such inclusion will assist the end user with interpreting and applying the listed provisions.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 098
USHGC 2024  Section: 206.0, 209.0, 222.0, 717.2 - 717.2.3

SUBMITTER: Jeff Persons
Chair, USHGC Geothermal Energy Systems Task Group

RECOMMENDATION:
Add new text

**717.2 District Load Profiles.** The district load profile of an ambient temperature loop (ATL) distributed energy system shall be identified and shall be included in the basis-of-design (BOD).

**717.2.1 System Asset Identification.** System assets shall be listed and included in the system design. The system assets shall include, but not be limited to, the following:
1. Building type and quantity.
2. Natural or constructed sources and sinks such as ground water, boreholes, etc.
3. Other renewable assets.
5. Potable and non-potable water or fluid sources.
6. Conventional assets such as boilers and cooling towers.
7. Other geothermal micro-districts or thermal highways.

**717.2.2 Driver Building.** The driver building profile shall be identified in an ATL distributed energy system and shall be reported in the design documents.

**717.2.3 Diversity Factor.** The diversity factor and/or anticipated wasted energy recovery component of the geothermal micro-district shall be identified by the designer, and this information shall be included in the drawings and specifications.

**206.0 – D –**
**Driver Building.** One or more building(s) or facility(s) that determine the upper and lower temperature limits of a hot fluid or cold fluid delivery system.

**209.0 – G –**
**Geothermal Micro-District.** A collection of buildings and facilities on an independently pumped ambient temperature loop (ATL) that supplies or receives energy. An independent segment served by a thermal highway. Also known as GeoMicroDistrict.

**222.0 – T –**
**Thermal Highway.** A collection of one or more geothermal micro-districts that acts as an energy transport system and supplies or accepts energy from multiple geothermal micro-districts, individual buildings, or other sources. Also known as convective circulation circuit.

**SUBSTANTIATION:**
Along with System Coefficient of Performance (SCOP), there are several additional unique characteristics and components that must be identified in the ATL design documents. These components must be identified accurately to communicate design intent. In addition, identification of system assets, the driver building(s), and diversity factors (e.g. wasted energy recovery) are imperative for building management system code development, validation/ commissioning processes, long term operations management, and future system expansion.
Furthermore, the definitions for "driver building," "geothermal micro-district," and "thermal highway" are being added to support the proposed language. Such terminology will assist with the enforcement of the section and provide clarity for the end user.

**COMMITTEE ACTION:** REJECT

**COMMITTEE STATEMENT:**
The Technical Committee has requested that additional time be provided to review the proposed requirements for district systems and ambient temperature loops. The Technical Committee will submit all comments and concerns via their letter ballots for Item #073, Item #074, Item #094, Item #095, Item #096, Item #097, and Item #098. It is recommended that the Geothermal Energy Systems Task Group reconvene to address all submitted feedback and resubmit proposals via public comments.

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16

**EXPLANATION OF AFFIRMATIVE:**

SMITH: This item is part of a multiple submission to update Chapter 7 and should not have been rejected but may need to be modified by the subcommittee and resubmitted in public comment.

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**PUBLIC COMMENT 1**

**Code Year:** 2024 USHGC  
**Section #:** 206.0, 209.0, 222.0, 717.2 - 717.2.3  
**SUBMITTER:** Jeff Persons  
Chair, USHGC Geothermal Energy Systems Task Group  
**Item #:** 098  
**Comment #:** 1  

**RECOMMENDATION:**
Accept as Modified

Request to accept the code change proposal **as submitted** by this public comment.

**SUBSTANTIATION:**
Along with System Coefficient of Performance (SCOP), there are several additional unique characteristics and components that must be identified in the ATL design documents. These components must be identified accurately to communicate design intent. In addition, identification of system assets, the driver building(s), and diversity factors (e.g., wasted energy recovery) are imperative for building management system code development, validation/ commissioning processes, long term operations management, and future system expansion.

Furthermore, the definitions for "driver building," "geothermal micro-district," and "thermal highway" are being added to support the proposed language. Such terminology will assist with the enforcement of the section and provide clarity for the end user.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 099
USHGC 2024 Section: 221.0, Chapter 8

SUBMITTER: IAPMO Staff - Update Extracts
NFPA 70 - Extract Update

RECOMMENDATION:
Revise text

221.0 - S -
Stand-Alone System. A system that is capable of supplying power independent of an electric production and distribution network. [NFPA 70:100]

CHAPTER 8
SOLAR PHOTOVOLTAIC SYSTEMS

809.0 Rapid Shutdown of PV Systems on Buildings.
809.1 Reduce Shock Hazard. (remaining text unchanged)

809.1.3 Initiation Device. The initiation device(s) shall initiate the rapid shutdown function of the PV system. The device’s “off” position shall indicate that the rapid shutdown function has been initiated for all PV systems connected to that device. For one-family and two-family dwellings an initiation device(s) shall be located at a readily accessible location outside the building.
For a single PV system, the rapid shutdown initiation shall occur by the operation of any single initiation device. Devices shall consist of at least one or more of the following:
(1) Service disconnecting means.
(2) PV system disconnecting means.
(3) Readily accessible switch that plainly indicates whether it is in the “off” or “on” position.
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. [NFPA 70:690.12(C)]

812.0 Wiring Methods Permitted.

812.2 Identification and Grouping. (remaining text unchanged)
812.2.1 Identification. PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means. Conductors relying on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size. The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (-) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with Section 200.6 of NFPA 70.
Exception: Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required. [NFPA 70:690.31(B)(1)
812.7 Photovoltaic System Direct-Current Circuits on or in a Building.

812.7.1 Flexible Wiring Methods. Where flexible metal conduit (FMC) smaller than the trade size \( \frac{3}{4} \) (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, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 6 feet (1829 mm) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means. [NFPA 70:690.31(D)(1)]

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

1. Exposed raceways, cable trays, and other wiring methods.
2. Covers or enclosures of pull boxes and junction boxes.
3. Conduit bodies in which any of the available conduit openings are unused.

The labels or markings shall be visible after installation. All letters shall be capitalized and shall be a minimum height of \( \frac{3}{8} \) of an inch (9.5 mm) in white on a red background. Labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 10 feet (3048 mm). Labels required by this section shall be suitable for the environment where they are installed. [NFPA 70:690.31(D)(2)]

816.0 Grounding and Bonding.

816.3 Ground-Fault Detection. The ground-fault protection device or system shall detect ground fault(s) in the PV array system dc circuit conductors, including any functional grounded conductors, and be listed for providing PV ground-fault protection. For dc-to-dc converters not listed as providing ground-fault protection, where required, listed ground fault protection equipment identified for the combination of the dc-to-dc converter and ground-fault protection device shall be installed to protect the circuit. [NFPA 70:690.41(B)(1)]

818.0 Equipment Grounding and Bonding.

818.1 General. (remaining text unchanged)

818.1.3 With Circuit Conductors. Equipment grounding conductors for the PV array and support structure (where installed) shall be contained within the same raceway or cable or otherwise run with the PV system conductors where those circuit conductors leave the vicinity of the PV array. [NFPA 70:690.43(C)]

824.0 Facilities with Stand-Alone Systems.

824.3 Buildings with Rapid Shutdown. (remaining text unchanged)

824.3.1 Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with more than one rapid shutdown type or PV systems with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system with a dotted line around areas that remain energized after rapid shutdown is initiated. [NFPA 70:690.56(C)(1)]

SUBSTANTIATION:
The above section is being revised to correlate with NFPA 70-2020 (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).

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

221.0 - S -

Stand-Alone System. A system that is capable of supplying power independent of an electric power production and distribution network. [NFPA 70:100]
CHAPTER 8
SOLAR PHOTOVOLTAIC SYSTEMS

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For a single PV system, the rapid shutdown initiation shall occur by the operation of any single initiation device. Devices shall consist of at least one or more of the following:
(1) Service disconnecting means.
(2) PV system disconnecting means.
(3) Readily accessible switch that plainly indicates whether it is in the “off” or “on” position.

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. [NFPA 70:690.12(C)]

812.0 Wiring Methods Permitted.

812.2 Identification and Grouping. (remaining text unchanged)

812.2.1 Identification. PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means. Conductors relying on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size. The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (-) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with Section 200.6 of NFPA 70.

Exception: Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required. [NFPA 70:690.31(B)(1)]

812.7 Photovoltaic System Direct-Current Circuits on or in a Building.

812.7.1 Flexible Wiring Methods. Where flexible metal conduit (FMC) smaller than the trade size 3/4 (metric designator 21) or Type MC cable smaller than 1 inch (25 mm) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 6 feet (1829 mm) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means. [NFPA 70:690.31(D)(1)]

812.7.2 Marking and Labeling Required. Unless located and arranged so the purpose is evident, the following wiring methods and enclosures that contain PV system dc circuit conductors shall be marked with the wording PHOTOVOLTAIC POWER SOURCE or SOLAR PV DC CIRCUIT by means of permanently affixed labels or other approved permanent marking:
(1) Exposed raceways, cable trays, and other wiring methods.
(2) Covers or enclosures of pull boxes and junction boxes.
(3) Conduit bodies in which any of the available conduit openings are unused.

The labels or markings shall be visible after installation. All letters shall be capitalized and shall be a minimum height of 3/8 of an inch (9.5 mm) in white on a red background. Labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 10 feet (3048 mm). Labels required by this section shall be suitable for the environment where they are installed. [NFPA 70:690.31(D)(2)]
816.0 Grounding and Bonding.

816.3 Ground-Fault Detection. The ground-fault protection device or system shall detect ground fault(s) in the PV system dc circuit conductors, including any functional grounded conductors, and be listed for providing PV ground-fault protection. For dc-to-dc converters not listed as providing ground-fault protection, where required, listed ground fault protection equipment identified for the combination of the dc-to-dc converter and ground-fault protection device shall be installed to protect the circuit. [NFPA 70:690.41(B)(1)]

818.0 Equipment Grounding and Bonding.

818.1 General. (remaining text unchanged)

818.1.3 With Circuit Conductors. Equipment grounding conductors for the PV array and support structure where installed shall be contained within the same raceway or cable or otherwise run with the PV system conductors where those circuit conductors leave the vicinity of the PV array. [NFPA 70:690.43(C)]

824.0 Facilities with Stand-Alone Systems.

824.3 Buildings with Rapid Shutdown. (remaining text unchanged)

824.3.1 Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with more than one rapid shutdown type or PV systems with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system with a dotted line around areas that remain energized after rapid shutdown is initiated. [NFPA 70:690.56(C)(1)]

COMMITTEE STATEMENT:
The modification updates the term "of" to "or" in Section 809.1.3 (Initiation Device) to correlate with the latest edition of NFPA 70.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Chapter 2, Chapter 8  Item #: 099

SUBMITTER: IAPMO Staff - Update Extracts  Comment #: 1

NFPA 70 - Extract Update

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

CHAPTER 8 (SOLAR PHOTOVOLTAIC SYSTEMS)

Part I – General.

801.0 General.

801.2 Applicability. This chapter applies to solar PV systems, other than those covered by Section 829.0 Part IX of this chapter, including the array circuit(s), inverter(s), and controller(s) for such systems [(see Figure 801.2(1) and Figure 801.2(2))]. The systems covered by this chapter include those interactive with other electric power production sources or stand-alone, or both. These PV systems may have ac or dc output for utilization. [NFPA 70:690.1]
Notes:

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

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

FIGURE 690.1(a)
IDENTIFICATION OF PV POWER SOURCE COMPONENTS [NFPA 70: FIGURE 690.1(a)]
Notes:

1. These diagrams are intended to be a means of identification for PV system components, circuits, and connections.
2. The PV system disconnect in these diagrams separates the PV system from all other systems.
3. Not all disconnecting means required by Section 810.0 through Section 811.1.4 are shown.
4. System grounding and equipment grounding are not shown. See Section 816.0 through Section 820.3.
5. Custom designs occur in each configuration, and some components are optional.

FIGURE 801.2(2)
IDENTIFICATION OF PV SYSTEM COMPONENTS IN COMMON CONFIGURATIONS
[NFPA 70:FIGURE 690.1(b)]
802.0 General Requirements.

802.2 Equipment. Inverters, electronic power converters, motor generators, PV modules, ac modules and ac module systems, dc combiners, dc-to-dc converters, PV rapid shutdown equipment (PVRSE), PV hazard control equipment (PVHCE), PV hazard control systems (PVHCS), dc circuit controllers, and charge controllers intended for use in PV systems shall be listed or be evaluated for the application and have a field label applied. [NFPA 70:690.4(B)]

802.3 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]

802.6 Electronic Power Converters Mounted in Not Readily Accessible Locations. Electronic power converters and their associated devices shall be permitted to be mounted on roofs or other areas that are not readily accessible. Disconnecting means shall be installed in accordance with Section 811.1. [NFPA 70:690.4(F)]

802.7 PV Equipment Floating on Bodies of Water. PV equipment floating on or attached to structures floating on bodies of water shall be identified as being suitable for the purpose and shall utilize wiring methods that allow for any expected movement of the equipment. [NFPA 70:690.4(G)]

803.0 Alternating-Current (ac) Modules and Systems.
804.0 Circuit Requirements.

804.1 Maximum Voltage. The maximum voltage of PV system dc circuits shall be the highest voltage between any two conductors of a circuit or any conductor and ground. The maximum voltage shall be used to determine the voltage and voltage to ground of circuits in the application of this chapter and NFPA 70. Maximum voltage shall be used for conductors, cables, equipment, working space, and other applications where voltage limits and ratings are used. PV system dc circuits on or in buildings shall be permitted to have a maximum voltage no greater than 1000 volts. PV system dc circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage no greater than 600 volts.

Where not located on or in buildings, listed dc PV equipment, rated at a maximum voltage no greater than 1500 volts, shall not be required to comply with Parts II and III of Article 490 of NFPA 70.

The maximum voltage of PV system dc circuits shall be the highest voltage between any two conductors of a circuit or any conductor and ground and shall comply with the following:

1. PV system dc circuits shall not exceed 1000 volts within or originating from arrays located on or attached to buildings and PV system dc circuits inside buildings.
2. PV system dc circuits shall not exceed 600 volts on or in one- and two-family dwellings.
3. PV system dc circuits exceeding 1000 volts shall comply with Section 812.7. [NFPA 70:690.7]

804.1.1 Photovoltaic Source and Output Circuits. In a dc PV source circuit or output circuit, the maximum PV system dc voltage for that PV source circuit shall be calculated in accordance with one of the following methods:

1. The sum of the PV module–rated open-circuit voltage of the series-connected modules in the PV string circuit 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. For crystalline and multicrystalline silicon modules, the sum of the PV module–rated open-circuit voltage of the series-connected modules in the PV string circuit corrected for the lowest expected ambient temperature using the correction factors provided in Table 804.1.1.
3. For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method maximum voltage calculation provided by a licensed professional electrical engineer. [NFPA 70:690.7(A)]

804.1.2 DC-to-DC Converter Source and Output Circuits. In a PV 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)]

804.2 Bipolar PV Source and Output Circuits. For monopole subarrays in bipolar systems, the maximum voltage shall be the highest voltage between the monopole subarray circuit conductors where one conductor of the monopole subarray circuit is connected to the functionally grounded reference. To prevent overvoltage in the event of a ground fault or arc fault, the monopole subarray circuits shall be isolated from ground. [NFPA 70:690.7(C)]

<table>
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<th>TABLE 804.1.1</th>
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<td>VOLTAGE CORRECTION FACTORS FOR CRYSTALLINE AND MULTICRYSTALLINE SILICON MODULES</td>
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<td>[NFPA 70: TABLE 690.7(A)]</td>
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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.

(portions of table not shown remain unchanged)

805.0 Circuit Sizing and Current.

805.1.1 Photovoltaic System Circuits. The maximum current shall be calculated in accordance with Section 805.1.1.1 through Section 805.1.1.6. [NFPA 70:690.8(A)(1)]

805.1.2 Photovoltaic Output Circuit Currents. The maximum current shall be the sum of parallel source circuit maximum currents as calculated in Section 805.1.1.1. [NFPA 70:690.8(A)(1)(b)]

805.1.3 805.1.2 PV DC-to-DC Converter Source Circuit Current. The maximum current shall be the sum of parallel connected dc-to-dc converter continuous output current ratings. [NFPA 70:690.8(A)(1)(eb)]

805.1.4 DC-to-DC Converter Output Circuit Current. The maximum current shall be the sum of parallel connected dc-to-dc converter source circuit currents as calculated in Section 805.1.1.3. [NFPA 70:690.8(A)(1)(d)]

805.1.5 805.1.3 Inverter Output Circuit Current. The maximum current shall be the inverter continuous output current rating. [NFPA 70:690.8(A)(1)(ec)]
805.1.3 Stand-Alone Inverter Input Circuit Current. The maximum input current shall be the stand-alone continuous inverter input current rating of the inverter when the inverter is producing rated power at the lowest input voltage. [NFPA 70:694.12(A)(3)]

805.2 Conductor Ampacity. Circuit conductors shall be sized to carry an ampacity not less than the larger of: (1) The minimum conductor size with an ampacity not less than the maximum currents calculated in Section 805.1 multiplied by 125 percent; or (2) The maximum currents calculated in accordance with Section 805.2.1 or Section 805.2.2. [NFPA 70:690.8(B)]

805.2.1 Before Application of Adjustment and Correction Factors. The minimum conductor size with an ampacity not less than the maximum currents calculated in Section 805.1 multiplied by 125 percent. [NFPA 70:690.8(B)(1)]

805.2.2 After Application of Adjustment and Correction Factors. The maximum currents calculated in Section 805.1 with adjustment and correction factors. [NFPA 70:690.8(B)(2)]

805.4 Sizing of Module Interconnection Conductors-Multiple PV String Circuits. Where a single overcurrent device is used to protect a set of parallel-connected module-PV string circuits, the ampacity of each conductor protected by the module interconnection conductors shall not be less than the sum of the rating of the single overcurrent device plus 125 percent of the short-circuit current from the other parallel-connected modules. Following:

(1) The rating of the overcurrent device.
(2) The sum of the maximum currents as calculated in Section 805.1.1.1 for the other parallel-connected PV string circuits protected by the overcurrent device. [NFPA 70:690.8(D)]

805.5 Standard Ampere Ratings. Standard ampere ratings shall be in accordance with Section 805.5.1 through Section 805.5.3.

805.5.1 Fuses and Fixed-Trip Circuit Breakers. 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)]

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805.5.3 Local Restricted Access Adjustable-Trip Circuit Breakers. (remaining text unchanged)

805.5.4 Remotely Accessible Adjustable-Trip Circuit Breakers. A circuit breaker(s) that can be adjusted remotely to modify the adjusting means shall be permitted to have an ampere rating(s) that is equal to the adjusted current setting (long-time pickup setting). Remote access shall be achieved by one of the following methods:

(1) Connected directly through a local nonnetworked interface.
(2) Connected through a networked interface complying with one of the following methods:
(a) The circuit breaker and associated software for adjusting the settings are identified as being evaluated for cybersecurity.
(b) A cybersecurity assessment of the network is completed. Documentation of the assessment and certification shall be made available to those authorized to inspect, operate, and maintain the system. [NFPA 70:240.6(D)]

806.0 Overcurrent Protection.

806.2 Overcurrent Device Ratings. Overcurrent devices used in PV system dc source circuits shall be listed for use in PV systems. Electronic devices that are listed to prevent backfeed current in PV system dc circuits shall be permitted to prevent overcurrent of conductors on the PV array side of the device. Overcurrent devices, where required, shall be rated in accordance with one of the following and permitted to be rounded up to the next higher standard size in accordance with Section 806.2.1:

(1) Overcurrent devices shall be rated not less than 125 percent of the maximum currents calculated in Section 805.1.
(2) An assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating. [NFPA 70:690.9(B)]

806.2.1 Overcurrent Devices Rated 800 Amperes or Less. The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

1. The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads.
2. The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).
3. The next higher standard rating selected does not exceed 800 amperes.

If the overcurrent protective device is an adjustable trip device installed in accordance with Section 806.2.1(1) through Section 806.2.1(3), it shall be permitted to be set to a value that does not exceed the next higher standard value above the ampacity of the conductors being protected as shown in Table 805.5.1 where restricted access in accordance with Section 805.5.3 is provided. [NFPA 70:240.4(B)]

806.2.2 Overcurrent Devices Rated over 800 Amperes. Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device defined in Section 805.5. [NFPA 70:240.4(C)]

806.3 Photovoltaic Source and Output System DC Circuits. A single overcurrent protective device, where required, shall be permitted to protect the PV modules, dc-to-dc converters, and conductors of each source circuit or the conductors of each output circuit. Where single overcurrent protection devices are used to protect 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(C)]

806.4 Power Transformers. Overcurrent protection for a transformer with a source(s) on each side of the transformer 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 Section 806.4.1.

Exception: A power transformer with a current rating on the side connected toward the 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(D)]

806.4.1 Installation. The following apply to the installation of transformers:

1. For the purpose of overcurrent protection, the primary side of transformers with sources on each side shall be the side connected to the largest source of available fault current.
2. Transformer secondary conductors shall be protected in accordance with 240.21(C) of NFPA 70. [NFPA 70:705.30(F)]

807.0 Stand-Alone Systems.

807.1 General. The wiring system connected to a stand-alone system shall be installed in accordance with Section 807.2. [NFPA 70:690.10]

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 807.2.5 and Section 807.2.7. [NFPA 70:710.15]

807.2.3 Single 120-Volt Supply. Stand-alone and isolated microgrid 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 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
MULTIWISE BRANCH CIRCUITS!

The warning sign(s) or label(s) shall comply with Section 810.1.2.4821.2. [NFPA 70:710.15(C)]

807.2.6 Backfed Circuit Breakers. Plug-in type backfed circuit breakers connected to an interconnected supply shall be secured in accordance with Section 807.2.6.1. Circuit breakers marked “line” and “load” shall not be backfed. [NFPA 70:710.16(F)]

810.1.7-807.2.6 Suitable for Backfeed. Fused disconnects, unless otherwise marked, shall be considered suitable for backfeed. Circuit breakers not marked “line” and “load” shall be considered suitable for backfeed. Circuit breakers marked “line” and “load” shall be considered suitable for backfeed or reverse current if specifically rated. [NFPA 70:705.42(D)(705.30(D)]
807.2.6.1 Backfed Devices. Plug-in-type overcurrent protection devices or plug-in type main lug assemblies that are backfed 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 board. [NFPA 70:408.36(D)]

807.2.7 Voltage and Frequency Control. The stand-alone or isolated microgrid supply power sources shall be controlled during operation so that voltage and frequency remain are supplied within suitable limits for compatible with the connected loads. [NFPA 70:710.15(GF)]

808.0 Arc-Fault Circuit Protection (Direct-Current).

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

Exception: For PV systems not installed on or in buildings, PV output circuits and dc-to-dc converter output circuits that utilize metal-clad cables, are installed in metallic raceways or metal clad cables, or installed in enclosed metallic cable trays, or are underground shall be permitted without arc-fault circuit protection; if the installation complies with at least one of the following: 

(1) The PV system dc circuits are not installed in or on buildings.
(2) The PV system dc circuits are located in or on detached structures whose sole purpose is to house support or contain PV system equipment shall not be considered buildings according to this exception. [NFPA 70:690.11]

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 to reduce shock hazard for firefighters in accordance with Section 809.1.1 through Section 809.4.809.1.3 and Section 825.2.

Exceptions:

(1) 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 of this section.
(2) PV equipment and circuits installed on nonenclosed detached structures including but not limited to parking shade structures, carports, solar trellises, and similar structures shall not be required to comply with this section. [NFPA 70:690.12]

809.1.1 Controlled Conductors. Requirements for controlled conductors shall apply to the following:

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

Exception: PV system circuits originating within or from arrays not attached to buildings that terminate on the exterior of buildings and PV system circuits installed in accordance with Section 230.6 of NFPA 70 shall not be considered controlled conductors for the purposes of Section 809.1. [NFPA 70:690.12(A)]

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 809.1.2.2. Equipment and systems shall be permitted to meet the requirements of both inside and outside the array as defined by the manufacturer's instructions included with the listing. [NFPA 70:690.12(B)]

809.1.2.2 Inside the Array Boundary. The PV system shall comply with one of the following:

(1) The PV system shall provide shock hazard control system listed for firefighters through the use of a PVHCS installed in accordance with the instructions included with the listing or field labeling. Where a hazard control system PVHCS requires initiation to transition to a controlled state, the rapid shutdown initiation device required in Section 809.1.3 shall perform this initiation.
(2) Controlled conductors located The PV system shall provide shock hazard control for firefighters by limiting the highest voltage inside the equipment or between any two conductors of a circuit or any conductor and ground inside array boundary shall be limited to not more than 80 volts within 30 seconds of rapid shutdown initiation. Voltage shall be measured between any two conductors and between any conductor and ground.
(3) PV arrays shall have no exposed wiring methods or conductive parts and be installed more than 8 feet (2438 mm) from exposed grounded conductive parts or ground. [NFPA 70:690.12(B)(2)]

809.1.3 Initiation Device. The-Where circuits identified in Section 809.1.1 are required to meet the requirements in Section 809.1.2, an initiation device(s) shall be provided and shall initiate the rapid shutdown function of the PV system. The device's "off" position shall indicate that the rapid shutdown function has been initiated for all PV systems connected to that device. For one-family and two-family dwellings an initiation device(s), where required, shall be located at a readily accessible outdoor location outside the building.
For a single PV system, the rapid shutdown initiation shall occur by the operation of any single initiation device. Devices shall consist of at least one or more of the following:

(1) Service disconnecting means.
PV system disconnecting means.

(3) Readily accessible switch that plainly indicates whether it is 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. [NFPA 70:690.12(C)]

**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)]

Part III – Disconnecting Means.

**810.0 Disconnecting Means.**

**810.1.1 Location.** The PV system disconnecting means shall be installed at a readily accessible location. Where a disconnecting means of systems for circuits operating above 30 V are readily accessible to unqualified persons, any an enclosure door or hinged cover that exposes live energized parts when open shall be have its door or cover locked or require a tool to be opened. [NFPA 70:690.13(A)]

**810.1.3 Suitable for Use.** If the PV system is connected to the supply side of the service disconnecting means as permitted in Article 230.82(E) of NFPA 70, the PV system disconnecting means shall be listed as suitable for use as service equipment. [NFPA 70-2017:690.13(C)]

**810.1.2 Maximum Number of Disconnects.** 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(C)]

**810.1.4 Type of Disconnect.** The PV system disconnecting means shall simultaneously disconnect the PV system conductors that are not solidly grounded from all conductors of other wiring systems. The PV system disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with Section 810.1.4.1. The PV system disconnecting means shall be one of the following:

1. A manually operable switch or circuit breaker.
2. A connector meeting the requirements of Section 814.1.4(1) or Section 814.1.4(3).
3. A pull-out switch with the required interrupting rating.
4. A remote-controlled switch or circuit breaker that is operable locally and opens automatically when control power is interrupted.
5. A device listed or approved for the intended application. [NFPA 70:690.13(E)]

**810.1.4.1 Lockable Disconnecting Means.** (remaining text unchanged)

**810.1.5 Ratings.** (remaining text unchanged)

**810.1.6 Type of Disconnect.** The PV system disconnecting means shall simultaneously disconnect the PV system conductors that are not solidly grounded from all conductors of other wiring systems. The PV system disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with Section 810.1.4.1. The PV system disconnecting means shall be one of the following:

1. An equipment disconnecting means in accordance with Section 811.1.3 shall be required to isolate dc circuits with a maximum circuit current over 30 amperes.
2. An isolating device in accordance with Section 811.1.2 shall be permitted for circuits other than those covered by Section 811.1.4(1). An isolating device as part of listed equipment where an interlock or similar means prevents the opening of the isolating device under load.
3. For circuits with a maximum circuit current of 30 amperes or less, an isolating device in accordance with Section 811.1.2. [NFPA 70:690.15(BA)]

**811.0 Disconnection of Disconnecting Means for Isolating Photovoltaic Equipment.**

**811.1 Isolating Devices General.** Disconnecting means of the type required in Section 811.1.4 shall be provided to disconnect ac PV modules, fuses, dc-to-dc converters inverters, and charge controllers from all conductors that are not solidly grounded. [NFPA 70:690.15]

**811.1.1 Type of Disconnecting Means.** Where disconnects are a connect is required to isolate equipment, the disconnecting means shall be one of the following applicable types:

1. An equipment disconnecting means in accordance with Section 811.1.3 shall be required to isolate dc circuits with a maximum circuit current over 30 amperes.
2. An isolating device in accordance with Section 811.1.2 shall be permitted for circuits other than those covered by Section 811.1.4(1). An isolating device as part of listed equipment where an interlock or similar means prevents the opening of the isolating device under load.
3. For circuits with a maximum circuit current of 30 amperes or less, an isolating device in accordance with Section 811.1.2. [NFPA 70:690.15(BA)]

**811.1.3 Equipment Disconnecting Means.** Equipment disconnecting means shall comply with the following:

1. Have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals. Equipment disconnecting means shall
2. Simultaneously disconnect all current-carrying conductors that are not solidly grounded to the circuit to which it is connected. Equipment disconnecting means shall
3. Be externally operable without exposing the operator to contact with energized parts and shall indicate whether in the open (off) or closed (on) position. Where not within sight or not within 10 feet (3048 mm) of the equipment, the disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall
be capable of being locked in accordance with Section 810.1.6.1. Equipment disconnecting means, where used, shall
(4) be one of the types in Section 810.1.6(1) through Section 810.1.6(5).
Equipment disconnecting means, other than those complying with Section 814.1, shall be marked in accordance with the warning in Section 810.1.2. If the line and load terminals can be energized in the open position. [NFPA 70:690.15(C)]

811.1.4 Location and Control. 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. Where disconnecting means of equipment operating above 30 volts are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open. comply with one or more of the following:
(1) Located within the equipment
(2) Located in sight from and readily accessible from the equipment for those to whom access is required
(3) Lockable in accordance with Section 810.1.4.1
(4) Provided with remote controls to activate the disconnecting means where the remote controls comply with one of the following:
(a) The disconnecting means and their controls are located within the same equipment.
(b) The disconnecting means is lockable in accordance with Section 810.1.4.1, and the location of the controls are marked on the disconnecting means. [NFPA 70:690.15(AD)]

Part IV – Wiring Methods.

812.0 Wiring Methods Permitted.

812.1 Wiring Systems. Wiring systems shall be in accordance with Section 812.1.1 through Section 812.1.7. All raceway and cable wiring methods included in NFPA 70, other wiring systems and fittings specifically listed for use in PV arrays, and wiring as part of a listed system shall be permitted.

812.1.1 Serviceability. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement. [NFPA 70:690.31(A)(1)]

812.1.2 Where Readily Accessible. Where not guarded, PV source and output circuits system dc circuit conductors operating at voltages greater than 30 volts that are installed in readily accessible locations, circuit conductors to unqualified persons shall be guarded or installed in Type MC cable, in multiconductor jacketed cable, or in raceway. [NFPA 70:690.31(A)(2)]

812.1.3 Conductor Ampacity. The ampacity of 221°F (105°C) and 257°F (125°C) conductors shall be permitted to be determined by Table 812.1.3(1). For ambient temperatures greater than 86°F (30°C), the ampacities of these conductors shall be corrected in accordance with Table 812.1.3(2). [NFPA 70:690.31(A)(3)]

812.1.4 Special Equipment. In addition to wiring methods included elsewhere in this chapter, other wiring systems specifically listed for use in PV systems shall be permitted. [NFPA 70:690.31(A)(4)]

| TABLE 812.1.3(1) |
| Ampacities of Insulated Conductors Rated Up To and Including 2000 Volts

<table>
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<td>1 Not more than three current-carrying conductors in raceway, cable, or earth (directly buried).</td>
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<tr>
<td>2 Based on ambient temperature of 86°F (30°C).</td>
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<tr>
<td>3 For temperatures 221°F (105°C) through 257°F (125°C).</td>
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<td>4 See Section 110.14(C) of NFPA 70 for conductor temperature limitations due to termination provisions.</td>
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(portions of table not shown remain unchanged)

| TABLE 812.1.3(2) |
| Correction Factors |

(portions of table not shown remain unchanged)
812.2 Identification and Grouping. PV system dc circuits and Class 1 remote control, signaling, and power limited circuits of a PV system shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway, as other non-PV systems, or inverter output circuits, unless the PV system dc circuits are separated from other circuits by a barrier or partition. PV system circuit conductors shall be identified and grouped as required by Section 812.2.1 through Section 812.2.3.

Exception: PV system dc circuits utilizing multiconductor jacketed cable or metal-clad cable assemblies or listed wiring harnesses identified for the application shall be permitted to occupy the same wiring method as inverter output circuits and other non-PV systems. All conductors, harnesses, or assemblies shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway. [NFPA 70:690.31(B)]

812.2.1 Conductors of Different Systems. Where not otherwise allowed in an equipment's listing, PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway as other non-PV systems or inverter output circuits unless separated from other circuits by a barrier or partition. Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required. [NFPA 70:690.31(B)(1)]

812.2.2 PV System DC Circuits. PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means: in accordance with the following:

(1) Conductors that rely on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size.

(2) The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (-) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with Section 200.6 of NFPA 70.

Exception: Where identification of the conductors is evident by spacing or arrangement, further identification shall not be required. [NFPA 70:690.31(B)(2)]

812.2.3 Grouping. Where the ac and dc conductors of more than one PV systems occupy the same junction box, null box, or raceway with a removable cover(s) wireway, the PV system ac and dc circuit conductors of each system shall be grouped separately by cable ties or similar means at least once and shall then be grouped at intervals not to exceed 6 feet (1829 mm).

Exception: The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious. [NFPA 70:690.31(B)(3)]

812.3 Cables. Type PV wire or cable and Type distributed generation (DG) cable shall be listed. [NFPA 70:690.31(C)]

812.3.1 Single-Conductor Cable. Single-conductor cables shall comply with the following:

(1) Single-conductor cable in exposed outdoor locations in PV system dc circuits within the PV array shall be permitted to be one of the following:

(a) PV wire or cable.

(b) Single-conductor cable marked sunlight resistant and Type USE-2 and Type RHW-2.

(2) Exposed cables sized 8 AWG or smaller shall be supported and secured at intervals not to exceed 2 feet (610 mm) by cable ties, straps, hangers, or similar fittings listed and identified for securement and support in outdoor locations. PV wire or cable shall be permitted in all locations where RHW-2 is permitted.

Exception: PV systems meeting the requirements of Section 829-2.830.2 shall be permitted to have support and securement intervals as defined in the engineered design.

(3) Exposed cables sized larger than 8 AWG shall be supported and secured at intervals not to exceed 54 inches (1372 mm) by cable ties, straps, hangers, or similar fittings listed and identified for securement and support in outdoor locations. [NFPA 70:690.31(C)(1)]

812.3.2 Cable Tray. Single-conductor PV wire or cable of all sizes or distributed generation (DG) cable of all sizes, with or without a cable tray rating, shall be permitted in cable trays installed in outdoor locations, provided that the cables are supported at intervals not to exceed 12 inches (305 mm) and secured at intervals not to exceed 4½ feet (1372 mm). Where installed in uncovered cable trays, ampacity of single-conductor PV wire smaller than 1/0 AWG, the adjustment factors for 1/0 AWG single conductor cable in Section 392.80(A)(2) of NFPA 70 shall be permitted to be used. Where single-conductor PV wire smaller than 1/0 AWG is installed in ladder ventilated trough cable trays, the following shall apply:

(1) All single conductors shall be installed in a single layer.

(2) Conductors that are bound together to comprise each circuit pair shall be permitted to be installed in other than a single layer.

(3) The sum of diameters of all single conductor cables shall not exceed the cable tray width. [NFPA 70:690.31(C)(2)]

812.3.3 Multiconductor Jacketed Cables. (remaining text unchanged)

812.5-812.3.4 Flexible Cords and Cables. Flexible cords and flexible cables, where connected to moving parts of tracking PV arrays, shall comply with Article 400 of NFPA 70 and shall be of a type identified as a hard service cord or portable power cable; they shall be suitable for extra-hard usage, listed for outdoor use, water resistant, and sunlight resistant. Allowable ampacities shall be in accordance with Section 400.5 of NFPA 70. Stranded copper PV wire shall be permitted to be connected to moving parts of tracking PV arrays in accordance with the minimum number of strands specified in Table 812.5-812.3.4 [NFPA 70:690.31(C)(4)]
812.4.1 Metal Raceways and Enclosures. Where inside buildings, PV system dc circuits that exceed 30 volts or 8 amperes shall be contained in metal raceways, in Type MC metal-clad cable that complies with Section 812.4.2(10)(b) or Section 812.4.2(10)(c), or in metal enclosures. Exception: PV hazard control systems installed in accordance with Section 809.1.2(1) shall be permitted to be provided with or listed for use with nonmetallic enclosure(s), nonmetallic raceway(s), and cables other than Type MC metal-clad cable(s), at the point of penetration of the surface of the building to the PV hazard control actuator. Wiring methods on or in buildings shall comply with the additional installation requirements in Section 812.7.1 and Section 812.7.2—Wiring methods on or in buildings shall comply with the installation requirements in Section 812.4.1 and Section 824.1. [NFPA 70:690.31(D)]

812.7.1 Flexible Wiring Methods. Where flexible metal conduit (FMC) smaller than the trade size ¾ (metric designator 21), or Type MC cable smaller than 1 inch (25 mm) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 6 feet (1829 mm) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means. [NFPA 70:690.31(D)(1)]

812.3.4 Types of Equipment Grounding Conductors. The each equipment grounding conductor run 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 1¼ (35 metric designator).
(d) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 6 feet (1829 mm).
(e) If used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with Section 812.4.2.1 shall be installed.
(f) If flexible metal conduit is constructed of stainless steel, a wire-type equipment grounding conductor or bonding jumper in accordance with Section 812.4.2.1 shall be installed.
(6) Listed liquidtight flexible metal conduit meeting all the following conditions:
(a) The conduit is terminated in listed fittings.
(b) For trade sizes 3/8 through ½ (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 ¾ through 1¼ (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 3/8 through ½ (12 through 16 metric designator) in the effective ground-fault current path.
(d) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 6 feet (1829 mm).
(e) If used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with Section 812.4.2.1 shall be installed.
(f) If liquidtight flexible metal conduit contains a stainless steel core, a wire-type equipment grounding conductor or a bonding jumper in accordance with Section 812.4.2.1 shall be installed.
(7) Flexible metallic tubing where the tubing is terminated in listed fittings and meeting the following conditions:
(a) The circuit conductors contained in the tubing are protected by overcurrent devices rated at 20 amperes or less.
(b) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the...
same effective ground-fault current path does not exceed 6 feet (1829 mm).

(8) Armor of Type AC cable as provided in Section 320.108 of NFPA 70.

(9) The copper sheath of mineral-insulated, metal-sheathed cable Type MI.

(10) 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 compliance with Section 842.7-3(e)(812.4.2(1)).

(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 metalsheath and equipment grounding conductors of the smooth or corrugated tube-type MC cable that is listed and identified as an equipment grounding conductor.

(11) Cable trays as permitted in Section 392.10 of NFPA 70 and Section 392.60 of NFPA 70.

(12) Cablebus framework as permitted in Section 370.60(1) of NFPA 70.

(13) Other listed electrically continuous metal raceways and listed auxiliary gutters.

(14) Surface metal raceways listed for grounding. [NFPA 70:250.118(A)]

812.4.2 Outside a Raceway or an Enclosure. If installed on the outside, the length of the bonding jumper or conductor or equipment bonding jumper shall not exceed 6 feet (1829 mm) and shall be routed with the raceway or enclosure.

Exception: An equipment bonding jumper or supply-side bonding jumper longer than 6 feet (1829 mm) shall be permitted at outside pole locations for the purpose of bonding or grounding isolated sections of metal raceways or elbows installed in exposed risers of metal conduit or other metal raceway, and for bonding grounding electrodes, and shall not be required to be routed with a raceway or enclosure. [NFPA 70:250.102(E)(2)]

812.9-812.5 Bipolar PV Systems. (remaining text unchanged)

812.6 Wiring Methods and Mounting Systems. Roof-mounted PV array mounting systems shall be permitted to be held in place with an approved means other than those required by Section 110.13 of NFPA 70 and shall utilize wiring methods that allow any expected movement of the array. [NFPA 70:690.31(F)]

812.7 Over 1000 Volts DC. Equipment and wiring methods containing PV system dc circuits with a maximum voltage greater than 1000 volts shall comply with the following:

(1) Shall not be permitted on or in one- and two-family dwellings.

(2) Shall not be permitted within buildings containing habitable rooms.

(3) Where installed on the exterior of buildings shall be located less than 10 feet (3048 mm) above grade. Wiring methods containing PV system dc circuits connected to this equipment shall not be permitted to attach to the building greater than 33 feet (10 058 mm) along the building surface from the equipment. [NFPA 70:690.31(G)]

Part V – Grounding and Bonding.

816.0 Grounding and Bonding.

816.1 PV System DC Circuit Grounding Configurations. One or more of the following system configurations shall be employed for PV system dc circuits:

(1) 2-wire PV array circuits with one functionally grounded conductor.

(2) Bipolar PV array circuits according to Section 804.2 with a functional ground reference (center tap).

(3) PV arrays not isolated from the inverter output circuit.

(4) Ungrounded PV array circuits.

(5) Solidly grounded PV array circuits as permitted in Section 816.2.

(6) PV systems that use other methods that accomplish equivalent system protection in accordance with Section 816.1.4 through Section 816.1.5 with Circuits protected by equipment listed and identified for the use. [NFPA 70:690.41(A)]

816.1.5 Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material 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 DC Ground-Fault Detector-Interrupter (GFDI) Protection. PV system dc circuits that exceed 30 volts or 8 amperes shall be provided with dc-ground-fault GFDI protection meeting the requirements of Section 816.3-816.2.1 and Section 816.4-816.2.2 to reduce fire hazards.

Solidly grounded PV source circuits with not more than two modules in parallel and not on or in buildings shall be permitted without ground-fault GFDI protection. [NFPA 70:690.41(B)]

816.3-816.2.1 Ground-Fault Detection. The ground-fault-protection GFDI device or system shall detect ground fault(s) in the PV system dc circuits, including any functionally grounded conductors, and be listed for providing ground-fault ground-fault protection. For dc-to-dc converters not listed as providing ground-fault GFDI protection, where required, the list ground-fault GFDI protection equipment identified for the combination of the dc-to-dc converter and ground-fault protection; the GFDI device shall be installed to protect the circuit. [NFPA 70:690.41(B)(1)]

816.4-816.2.2 Isolating Faulted Circuits. The faulted circuits shall be controlled by one of the following methods:

(1) The current-carrying conductors of the faulted circuit shall be automatically disconnected.

(2) The device providing ground-fault GFDI protection fed by the faulted circuit shall automatically cease to supply power to output circuits and interrupt the faulted PV system dc circuits from the ground reference in a functionally grounded system. [NFPA 70:690.41(B)(2)]
816.2.3 Indication of Faults. The GFDI protection equipment shall provide indication of ground faults at a readily accessible location. [NFPA 70:690.41(B)(3)]

817.0 Point of PV System DC Circuit Grounding Connection.
817.1 Circuits with GFDI Protection Grounding Connection. Systems with a ground fault protective device Circuits protected by GFDI equipment in accordance with Section 816.2 shall have any current-carrying conductor circuit-to-ground connection made by the ground fault protective device-GFDI equipment. [NFPA 70:690.42(A)]

817.2 Solidly Grounded Circuits. For solidly grounded PV systems dc circuits, the dc circuit grounding connection shall be made at-from any single point on the PV output circuit dc system to a point in the grounding electrode system in Section 820.2. [NFPA 70:690.42(B)]

818.0 Equipment Grounding and Bonding.
818.1 General. Exposed non-current-carrying metal parts of PV module frames, electrical equipment, and conductor enclosures of PV systems shall be connected to an equipment grounding conductor in accordance with Section 818.1.3.1 or Article 250.136 of NFPA 70, regardless of voltage. Equipment grounding conductors and devices shall comply with Section 818.1.1 through Section 818.1.4. [NFPA 70:690.43]

818.1.1 Photovoltaic Mounting Systems and Devices. Devices and systems used for mounting PV modules that are also used for bonding module frames shall be listed, labeled, and identified for bonding PV modules. Devices that mount adjacent PV modules shall be permitted to bond adjacent PV modules. [NFPA 70:690.43(A)]

818.1.3 With Circuit Conductors Location. Equipment grounding conductors for the PV array and support structure where installed shall be contained within the same raceway or cable or otherwise permitted to be run with separately from the PV system conductors where those within the PV array. Where PV system circuit conductors leave the vicinity of the PV array, equipment grounding conductors shall comply with Section 818.1.3.1. [NFPA 70:690.43(C)]

818.2-818.1.3.1 Equipment Fastened In Place or Connected by Permanent Wiring Methods (Fixed)——Grounding. Unless connected 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, if grounded, shall be connected to an equipment grounding conductor by one of the following methods:

(1) By connecting to any of the equipment grounding conductors permitted by Section 821.3(2) through Section 821.7.3(14).
Exception: As provided in Section 250.130(C) of NFPA 70, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

(2) By connecting to an equipment grounding conductor of the wire type that is contained within the same raceway, contained within the same cable, or otherwise run with the circuit conductors. Exceptions:

(1) As provided in Article 250.130(C) of NFPA 70, 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 70:250.134]

819.0 Size of Equipment Grounding Conductors.

819.4-819.2 Equipment Grounding Conductor Installation. An equipment grounding conductor shall be installed in accordance with Section 819.2.1, Section 819.2.2, and Section 819.2.3. [NFPA 70:250.120]

819.2.1 Raceway, Cable Trays, Cable Armor, Cablebus, or Cable Sheaths. Where if it consists of a raceway, cable tray, cable armor, cablebus framework, or cable sheath or where if 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 of raceway or cable used. All connections, joints, and fittings shall be made tight using suitable tools. [NFPA 70:250.120(A)]

819.2.2 Aluminum and Copper-Clad Aluminum Conductors. Equipment grounding conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Unless part of a suitable an applicable cable wiring method in accordance with Chapter 3 of NFPA 70, bare or covered conductors shall not be installed where if subject to corrosive conditions or be installed in direct contact with concrete, masonry, or the earth.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 18 inches (457 mm) of the bottom of the enclosure.

(3) Aluminum or copper-clad aluminum conductors external to buildings or enclosures shall not be terminated within 18 inches (457 mm) of the earth, unless terminated within a listed wire connector system. [NFPA 70:250.120(B)]

819.4-819.2.3 Equipment Grounding Conductors Smaller Than 6 AWG. Where if not routed with circuit conductors as permitted in Article Section 250.130(C) of NFPA 70 and Section 818.2.1.3.1(2)(Exception-2), equipment grounding conductors smaller 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 if not subject to physical damage. [NFPA 70:250.120(C)]
820.0 Grounding Electrode System.

820.1 Electrode System. All grounding electrodes as described in Section 820.1.1 through Section 820.1.7 that are present at each building or structure served shall be bonded together to form the grounding electrode system. Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in Section 820.1.4 through Section 820.1.8 shall be installed and used.

Exception: Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcing bars, or rebar is not accessible for use without disturbing the concrete. [NFPA 70:250.50]

Grounding of electrode systems shall comply with Section 820.2 and Section 820.3.

<table>
<thead>
<tr>
<th>Table 819.1</th>
<th>Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes: 1</td>
<td>Where necessary to comply with Section 816.1.5 of this chapter or Section 250.4(B)(4) of NFPA 70, the equipment grounding conductor shall be sized larger than given in this table.</td>
</tr>
<tr>
<td>2</td>
<td>See installation restrictions in Section 819.1.2.</td>
</tr>
<tr>
<td>(portions of table not shown remain unchanged)</td>
<td></td>
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</tbody>
</table>

820.1.3 Concrete-Encased Electrode. A concrete-encased electrode shall consist of at least 20 feet (6096 mm) of either of the following:

1. One or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rebar of not less than ½ of an inch (12.7 mm) in diameter, installed in one continuous 20 foot (6096 mm) length, or if in multiple pieces, the rebar shall be connected together by the usual steel tie wires, exothermic welding, welding, or other effective means to create a 20 foot (6096 mm) or greater length; or

2. Bare copper conductor not smaller than 4 AWG.

Metallic components shall be encased by 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. 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. [NFPA 70:250.52(A)(3)]

820.1.5 Rod and Pipe Electrodes. Rod and pipe electrodes shall 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 not be smaller than trade size ¾ (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 at least 3/8 of an inch (15.9 mm) in diameter, unless listed. [NFPA 70:250.52(A)(5)]

820.1.9 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 rebar described in Section 680.26(B)(1) and Section 680.26(B)(2) of NFPA 70. [NFPA 70:250.52(B)]

820.2 Buildings or Structures Supporting a PV Array. A building or structure(s) supporting a PV system shall utilize a grounding electrode system installed in accordance with Part III 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 grounding conductor shall be sized in accordance with Section 819.1. For specific PV system grounding configurations permitted in Section 816.1, one of the following conditions shall apply:

1. For PV systems that are not solidly grounded, the equipment grounding conductor for the output of the PV system, where connected to associated distribution equipment connected to a grounding electrode system, shall be permitted to be the only connection to ground for the system.

2. 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 820.2.1. [NFPA 70:690.47(A)]
820.2.1 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 820.2.2 and Section 820.2.3, except as permitted by Section 820.2.4 through Section 820.2.6. The grounding electrode conductor for a dc system shall meet the sizing requirements in this section but shall not be required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum. [NFPA 70:250.166]

820.2.2 Not Smaller Than the Neutral Conductor. Where-if the dc system consists of a three-wire balancer set or a balancer winding with overcurrent protection as provided in Section 445.12(D) of NFPA 70, the grounding electrode conductor shall not be smaller than the neutral conductor and not smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum. [NFPA 70:250.166(A)]

820.2.3 Not Smaller Than the Largest Conductor. Where-if the dc system is other than as in Section 820.2.2, the grounding electrode conductor shall not be smaller than the largest conductor supplied by the system; and not smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum. [NFPA 70:250.166(B)]

820.2.4 Connected to Rod, Pipe, or Plate Electrodes. Where-if connected to rod, pipe, or plate electrodes as in Section 820.1.5 or Section 820.1.7, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire. [NFPA 70:250.166(C)]

820.2.5 Connected to a Concrete-Encased Electrode. Where-if connected to a concrete-encased electrode as in Section 820.1.3, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 4 AWG copper wire. [NFPA 70:250.166(D)]

820.2.6 Connected to a Ground Ring. Where-if connected to a ground ring as in Section 820.1.4, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than the conductor used for the ground ring. [NFPA 70:250.166(E)]

820.3 Grounding Electrodes and Grounding Electrode Conductors Additional Auxiliary Electrodes for Array Grounding. (remaining text unchanged)

Part VI – Marking.

821.0 Marking.

821.1 Directory Identification of Power Sources. A permanent plaque or directory—Permanent plaques, labels, or directories—shall be installed at each service equipment location, or at an approved readily visible location. The plaque or directory shall in accordance with the following:

(1) Denote the location of each power source disconnecting means for the building or structure and be grouped with other plaques or directories for other on-site sources. The plaque or directory shall be marked with the wording “CAUTION: MULTIPLE SOURCES OF POWER.” Any posted diagrams shall be correctly oriented with respect to the diagram’s location. The marking shall comply with Section 810.1.2.1.

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

(2) Indicate the emergency telephone numbers of any off-site entities servicing the power source systems.

(3) Be marked with the wording “CAUTION: MULTIPLE SOURCES OF POWER.” The marking shall comply with Section 821.2.

[NFPA 70:705.10]

840.1.2.4-821.2 Field-Applied Hazard Markings. Where caution, warning, or danger signs or hazard markings such as labels or signs are required by this chapter, the labels-markings shall meet the following requirements:

(1) The marking shall be of sufficient durability to withstand the environment involved and warn of the hazards using effective words, colors, symbols, or any combination thereof.

(2) The label-marking shall be permanently affixed to the equipment or wiring method and shall not be handwritten.

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

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

821.2 Modules. Modules and ac modules shall be marked in accordance with their listing. [NFPA 70:690.51]

821.3 Format. The marking requirements in Section 840.1.2.1-821.2 shall be provided in accordance with the following:

(1) Red background

(2) White lettering

(3) Not less than 3/8 of an inch (9.5 mm) letter height

(4) Capital letters

(5) Made of reflective weather-resistant material

822.0 Marking Direct-Current Photovoltaic Power Source Circuits.

822.1 Labeling. A permanent readily visible label indicating the highest maximum dc voltage in a PV system, calculated in accordance with Section 804.1 through Section 804.2, shall be provided by the installer at one of the following locations:

(1) DC PV system disconnecting means.
822.2 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]

823.0 Photovoltaic Systems Connected to Energy Storage Systems.
823.1 Marking. The PV system output circuit conductors shall be marked to indicate the polarity where connected to energy storage systems. [NFPA 70:690.55]

823.0 Disconnecting Means.
810.1.2 823.1 Markings. Each PV system disconnecting means shall plainly indicate whether in the open (off) or closed (on) position and be permanently marked “PV SYSTEM DISCONNECT” or equivalent. Additional markings shall be permitted based upon the specific system configuration. For PV system disconnecting means where the line and load terminals may be energized in the open position, the device shall be marked with the following words or equivalent:

WARNING:
ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION

The warning sign(s) or label(s) shall comply with 410.21(B) Section 821.2. [NFPA 70:690.13(B)]

824.0 Wiring Methods.
812.7.2 824.1 Marking and Labeling Required. Unless located and arranged so the purpose is evident, the following wiring methods and enclosures that contain PV system dc circuit conductors shall be marked with the wording PHOTOVOLTAIC POWER SOURCE or SOLAR PV DC CIRCUIT by means of permanently affixed labels or other approved permanent marking:
(1) Exposed raceways, cable trays, and other wiring methods.
(2) Covers or enclosures of pull boxes and junction boxes.
(3) Conduit bodies in which any of the available conduit openings are unused.

The labels or markings shall be visible after installation. All letters shall be capitalized and shall be a minimum height of 3/8 of an inch (9.5 mm) in white on a red background. Labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 10 feet (3048 mm). Labels required by this section shall be suitable for the environment where they are installed. [NFPA 70:690.31(D)(2)]

824.0–825.0 Facilities with Stand-Alone Systems.
824.1–825.1 Identification of Power Sources Plaques or Directories. A permanent plaque, label, or directory shall be installed at a building supplied by a stand-alone system at each service equipment disconnecting means location, or at an approved readily visible location. The plaque, label, or directory shall denote the location of each power source disconnecting means for the building or be grouped with other plaques or directories for other on-site sources. Where multiple sources supply the building, the plaque or directory shall be marked with the wording “CAUTION: MULTIPLE SOURCES OF POWER.” The markings shall comply with Section 810.1.2.1821.1.

Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually. [NFPA 70:710.10]

824.2 Facilities with Utility Services and Photovoltaic Systems. Plaques or directories shall be installed in accordance with Section 821.1, Section 824.2.1, and Section 824.2.2, as required. [NFPA 70:690.56(B)]

824.2.1 Source Directory. A permanent directory denoting all dc electric power sources operating to supply the dc microgrid shall be installed at each source location capable of acting as the primary dc source. [NFPA 70:712.10(A)]

824.2.2 Building Directory. A building supplied by a dc microgrid system shall have a permanent plaque or directory installed outside the building at each service equipment location or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means on or in the building or be grouped with other plaques or directories for other on-site sources.

Exception: Multiple power production sources that are grouped at one location shall be permitted to be identified as a group. [NFPA 70:712.10(B)]

824.3–825.2 Buildings with Rapid Shutdown. Buildings with PV systems shall have a permanent label located at each service equipment location to which the PV systems are connected or at an approved readily visible location and shall indicate the location of rapid shutdown initiation devices. The label shall include a simple diagram of a building with a roof and shall include the following words:

SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN.
TURN RAPID SHUTDOWN SWITCH TO THE “OFF” POSITION TO SHUT DOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY.
The title "SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN" shall utilize capitalized characters with a minimum height of $\frac{3}{16}$ of an inch (9.5 mm) in black on yellow background, and the remaining characters shall be capitalized with a minimum height of $\frac{3}{16}$ of an inch (4.8 mm) in black on white background have these letters capitalized and having a minimum height of $\frac{3}{8}$ inch (9.5 mm). All text shall be legible and contrast the background. [NFPA 70:690.56(C)690.12(D)] [see Figure 824.3825.2]

**FIGURE 824.3825.2**
LABEL FOR ROOF-MOUNTED PV SYSTEMS WITH RAPID SHUTDOWN
[NFPA 70: FIGURE 690.56(C)690.12(D)]

824.3.1-825.2.1 Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with more than one rapid shutdown type or PV systems with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system with a dotted line around areas that remain energized after rapid shutdown is initiated. [NFPA 70:690.56(C)(1)690.12(D)(1)]

824.3.2-825.2.2 Rapid Shutdown Switch. A rapid shutdown switch shall have a label that includes the following wording located on or no more than 3 feet (914 mm) from the switch:

RAPID SHUTDOWN SWITCH FOR
SOLAR PV SYSTEM

The label shall be reflective, with all letters capitalized and having a minimum height of $\frac{3}{8}$ of an inch (9.5 mm), in white on red background. [NFPA 70:690.56(C)(2)690.12(D)(2)]

Part VII – Connection to Other Sources.

825.0-826.0 Connection to Other Sources.
825.1-826.1 PV Systems. PV systems connected to other sources shall be installed in accordance with Parts I and II of Article 705 and Article 712 of NFPA 70. [NFPA 70:690.59]


826.0-827.0 Energy Storage Systems.
826.1-827.1 General. An energy storage system connected to a PV system shall be installed in accordance with Part VIII of this chapter and Article 706 of NFPA 70. [NFPA 70:690.71]

827.0-828.0 Batteries.
827.1-828.1 Battery Locations. (remaining text unchanged)

828.0-829.0 Self-Regulating Charge Control.
828.1-829.1 General. The PV source circuit shall be considered to comply with the requirements of Section 828.1.1 through Section 828.1.5 for charge control of a battery without the use of separate charge control equipment if the circuit meets both of the following:

1. The PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells—and,
2. The maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer. [NFPA 70:690.72]

828.1.1-829.1.1 Charge Control. (remaining text unchanged)
828.1.2-829.1.2 Diversion Charge Controller, Sole Means of Regulating Charging. (remaining text unchanged)
828.1.3-829.1.3 Diversion Charge Controller, Circuits with Diversion Charge Controller and Diversion Load. (remaining text unchanged)

828.1.4-829.1.4 Energy Storage Systems Using Utility-Interactive Inverters. Systems using interactive inverters to control energy storage state-of-charge by diverting excess power into an alternate electric power production and distribution system, such as utility, shall comply with the following:

1. These systems shall not be required to comply with Section 828.1.3-829.1.3.
2. These systems shall have a second, independent means of controlling the ESS charging process for use when the alternate system is not available or when the primary charge controller fails or is disabled. [NFPA 70:706.33(B)(3)]

828.1.5-829.1.5 Charge Controllers and DC-to-DC Converters. (remaining text unchanged)
Part IX – Large-Scale Photovoltaic (PV) Electric Power Production Facility.

829.0-830.0 Large-Scale Photovoltaic (PV) Electric Power Production Facility.

829.1-830.1 Scope. Section 829.2 through Section 829.9 Part IX of this chapter covers the installation of large-scale PV electric supply stations with an inverter generating capacity of no less than 5000 kW, and not under exclusive utility control. [NFPA 70:691.1] (see Figure 830.1)

![Diagram of Large-Scale PV Electric Supply Station](image)

**FIGURE 830.1**

**IDENTIFICATION OF LARGE-SCALE PV ELECTRIC SUPPLY STATION COMPONENTS**

[NFPA 70:FIGURE 691.1]

**Notes:**
1. The diagram is for informational purposes only and is not representative of all potential configurations.
2. Custom designs occur in each configuration, and some components are optional.

829.2-830.2 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.
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.
6. The station shall be monitored from a central command center.
7. The station shall have an inverter generating capacity of at least 5000 kW. [NFPA 70:691.4]

829.3-830.3 Equipment Approval. All electrical equipment shall be approved for installation by one of the following:

1. Listing and labeling.
2. Be evaluated for the application and have a field label applied.
3. Where products complying with Section 829.3(1) or Section 829.3(2) are not available, by engineering review validating that the electrical equipment is evaluated and tested to relevant standards or industry practice. [NFPA 70:691.5]

829.4-830.4 Engineered Design. (remaining text unchanged)

829.5-830.5 Conformance of Construction to Engineered Design. (remaining text unchanged)

829.6-830.6 Direct-Current Operating Voltage. (remaining text unchanged)

829.7-830.7 Disconnection of Disconnecting Means for Isolating Photovoltaic Equipment. Isolating devices Disconnecting means for equipment shall not be required within sight of equipment and shall be permitted to be located remotely from equipment. The engineered design required by Section 829.4 shall document disconnection procedures and means of isolating equipment.

Buildings whose sole purpose is to house and protect supply station equipment shall not be required to comply with Section 809.1 through 809.1.3. Written standard operating procedures shall be available at the site detailing necessary shutdown procedures in the event of an emergency. [NFPA 70:691.9]

829.8-830.8 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 829.4. [NFPA 70:691.10]

829.9-830.9 Fence Bonding and Grounding. Fence grounding requirements and details shall be included in the documentation required in Section 829.4. [NFPA 70:691.11]
CHAPTER 2 (DEFINITIONS)

203.0 – A –
Alternating-Current (AC) Module (Alternating-Current Photovoltaic Module). A complete environmentally protected unit consisting of solar cells, inverter, and other components, designed to produce ac power. [NFPA 70:690-2100]

Array. A mechanically and electrically integrated grouping of modules with support structure, including any attached system components such as inverter(s) or dc-to-dc converter(s) and attached associated wiring. [NFPA 70:690-2100]

206.0 – D –
DC-to-DC Converter Circuit. The dc circuit conductors connected to the output of a dc-to-dc converter. [NFPA 70:100]

DC-to-DC Converter Output Circuit. The dc circuit conductors connected to the output of a dc combiner for the dc-to-dc converter source circuits. [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. An enclosure that includes devices used to connect two or more PV system dc circuits in parallel. [NFPA 70:690-2100]

Diversion Charge Controller. Equipment that regulates the output of a source or charging process of a battery or other energy storage device by diverting power from energy storage to dc-direct-current or ac-alternating-current loads, or to an interconnected utility service. [NFPA 70:694-2100]

207.0 – E –
Electric Supply Stations. Locations containing the generating stations and substations, including their associated generator, storage battery, transformer, and switchgear areas. [NFPA 70:694-2100]

209.0 – G –
Generating Capacity, Inverter. The sum of parallel-connected inverter maximum continuous output power at 104°F (40°C) in watts (W), or kilowatts (kW), volt-amperes (VA), or kilovolt-amperes (kVA). [NFPA 70:100]

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 70:694-2100]

Grounded, Functionally. A system that has an electrical ground reference for operational purposes that is not solidly grounded. [NFPA 70:742-2100]

210.0 – H –
Hybrid System. A system comprised of multiple power sources. These power sources could include photovoltaics, 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]

211.0 – I –
Interactive System. An electric power production system that is operating in parallel with and capable of delivering energy to an electric primary source supply system. [NFPA 70:100]

Inverter, Multimode. Equipment having the capabilities of both the interactive inverter and the stand-alone inverter. Inverter equipment capable of operating in both interactive and island modes. [NFPA 70:100]

Inverter, Stand-alone. Inverter equipment having the capabilities to operate only in island mode. [NFPA 70:100]
Photovoltaic Module. A complete, environmentally protected unit consisting of solar cells and other components designed to produce dc power. [NFPA 70:690.2100]

Photovoltaic Output Circuit. The dc circuit conductors from two or more connected PV source circuits to their point of termination. [NFPA 70:690.2]

Photovoltaic Source Circuit. The PV dc circuit conductors between modules in a PV string circuit, and from modules PV string circuits or dc combiners, to dc combinators, electronic power converters, or a dc PV system disconnecting means. [NFPA 70:690.2100]

Photovoltaic String Circuit. The PV source circuit conductors of one or more series-connected PV modules. [NFPA 70:100]

Photovoltaic System DC Circuit. Any dc conductor in PV source circuits, PV output-string circuits, and PV dc-to-dc converter source circuits, and dc-to-dc converter output circuits. [NFPA 70:690.2100]

Solar Cell. The basic PV-photovoltaic device that generates dc electricity when exposed to light. [NFPA 70:690.2100]

Stand-Alone System. A system that is capable of supplying power independent of not connected to an electric power production and distribution network. [NFPA 70:100]

Note: NFPA 70 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:
The above section is being revised to correlate with NFPA 70-2023 (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).

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 100

USHGC 2024 Section: 802.2.1, Table 802.2.1, 802.6, 828.1, Table 901.1

SUBMITTER: John Taecker
UL LLC

RECOMMENDATION:
Revise 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. Equipment shall be installed in accordance with its listing and the manufacturer’s installation instructions.

<table>
<thead>
<tr>
<th>TABLE 802.2.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARDS FOR PV EQUIPMENT</td>
</tr>
<tr>
<td>EQUIPMENT</td>
</tr>
<tr>
<td>Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures</td>
</tr>
<tr>
<td>Enclosed and Dead-Front Switches</td>
</tr>
<tr>
<td>Disconnect Switches</td>
</tr>
<tr>
<td>Low-Voltage Fuses - Fuses</td>
</tr>
<tr>
<td>Building-Integrated PV Roof Coverings</td>
</tr>
<tr>
<td>PV Fuses</td>
</tr>
<tr>
<td>PV Junction Boxes</td>
</tr>
<tr>
<td>Rapid Shutdown Equipment and Systems (PV Hazard Control)</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

802.6 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.

828.0 Self-Regulating Charge Control.

828.1 General. The PV source circuit shall be considered to comply with the requirements of Section 828.1.1 through Section 828.1.5 if:

1. The PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells, and
2. The maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer. [NFPA 70:690.72]

A charge controller that is integral with an external inverter shall comply with UL 1741.
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>UL 98B-2015</td>
<td>Outline of Investigation for Enclosed and Dead-front Switches for use in Photovoltaic Systems</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 248-2019</td>
<td>Low-Voltage Fuses – Part 19: Photovoltaic Fuses (with revisions through February 28, 2020)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<tr>
<td>UL 489B-2016</td>
<td>Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures for Use with Photovoltaic (PV) Systems (with revisions through May 19, 2021)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<td>UL 508I-2015</td>
<td>Outline of Investigation for Disconnect Switches Intended for Use in Photovoltaic Systems</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<tr>
<td>UL 2579-2013</td>
<td>Outline of Investigation for Low-Voltage Fuses - Fuses for Photovoltaic Systems</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 3730-2014</td>
<td>Photovoltaic Junction Boxes (with revisions through June 11, 2021)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 3741-2020</td>
<td>Photovoltaic Hazard Control</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 7103-2019</td>
<td>Outline of Investigation for Building-Integrated Photovoltaic Roof Coverings</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 248, UL 489B, UL 3730, and UL 3741 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 98B, UL 508I, UL 2579, and UL 7103 do not meet the requirements for consensus referenced standards 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.

SUBSTANTIATION:
Listed equipment should be installed in accordance with its listing and the manufacturer’s installation instructions. This is fundamental for all references in codes for proper installation.

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 2020 National Electrical Code (NEC) includes Annex A (Product Safety Standards) which provides product safety standards used for product listings 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.

Furthermore, Section 828.1 is being revised to remove language referencing UL 1741, and Section 802.6 is being deleted in its entirety. Both UL 1703 and UL 1741 are already addressed in Section 802.2.1 and Table 802.2.1. Thus the language in Section 802.6 and Section 828.1 is redundant and unnecessary.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments
PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 802.2.1, Table 901.1  Item #: 100
SUBMITTER: John K. Taecker, PE  UL Solutions  Comment #: 1

RECOMMENDATION: Accept as Modified

Request to accept the code change proposal as modified by this public comment.

### TABLE 802.2.1
STANDARDS FOR PV EQUIPMENT

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-Voltage Fuses—Fuses</td>
<td>UL 2579</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

### TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 2579-2013</td>
<td>Outline of Investigation for Low Voltage Fuses—Fuses for Photovoltaic Systems (WITHDRAWN)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
Table 802.2.1 (Standards for PV Equipment) and Table 901.1 (Referenced Standards) are being revised to remove reference to a withdrawn standard, UL 2579.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16
VOTING RESULTS: AFFIRMATIVE: 16
APPENDIX E
NET ZERO AND NET POSITIVE APPLICATIONS

E 101.0 General.
E 101.1 Applicability. The purpose of this appendix is to provide guidelines for achieving net zero energy and net positive energy buildings through the use of energy efficient equipment and renewable energy systems.

E 102.0 Definitions.
E 102.1 General. For the purposes of this appendix, the following definitions shall apply:
Energy Loading Order. A design pathway aligned with achieving net zero energy consumption through energy efficient strategies and measures.
Energy Star. A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. Energy Star is a voluntary program designed to identify and promote energy-efficient products and practices.
Net Zero Energy Building. A building with net zero energy consumption; the total annual amount of energy consumed by a building is equal to the amount of on-site renewable energy generated.
Renewable Energy Sources. Energy from solar, wind, biomass, or hydro, or extracted from hot fluid or steam heated within the earth.

E 103.0 General Regulations.
E 103.1 Installation. Systems covered by this appendix shall be installed in accordance with this code, other applicable codes, and the manufacturer’s installation and operating instructions.
E 103.1.1 Renewable Energy Systems. Renewable energy systems shall be designed and installed as follows:
(1) Solar thermal systems in accordance with Chapter 5.
(2) Geothermal energy systems in accordance with Chapter 7.
(3) Solar photovoltaic systems in accordance with Chapter 8 and IAPMO IS 34.
E 103.1.2 Water Conservation. Water efficiency and conservation shall be in accordance with the Water Efficiency and Sanitation Standard (WE•Stand).
E 103.2 Qualifications. Where permits are required, the Authority Having Jurisdiction shall have the authority to require contractors, installers, or service technicians to demonstrate competency. Where determined by the Authority Having Jurisdiction, the contractor, installer, or service technician shall be licensed to perform such work.

E 104.0 Certification.
E 104.1 General. Net zero buildings shall be certified by one of the following agencies:
(1) U.S. Green Building Council (USGBC);
(2) International Living Future Institute (ILFI);
(3) Department of Energy (DOE);
(4) Earth Advantage; or
(5) Other equivalent approved agencies.
E 105.0 Energy Loading Order.
E 105.1 General. New and retrofit construction of residential and commercial buildings shall be designed and installed in the following energy loading order:
(1) Building envelope
(a) Reduction of infiltration
(b) Insulation
(c) Glazing of windows and doors
(2) Water heating appliances in accordance with the Energy Star program.
(3) Space heating
(4) Lighting
(5) Other appliances
(6) Air-Conditioning
(7) Renewable energy systems

E 106.0 Sustainable Practices.
E 106.1 General. This section covers provisions that promote sustainable practices by enhancing the design and construction of mechanical systems to result in a positive long-term environmental impact. (See Figure E 106.1.)

Notes:
1. The delivered energy may consist of renewable and nonrenewable sources while only renewable energy is exported from the site boundary.
2. Renewable energy generation may be from bulk power systems with utility-scale solar, geothermal, hydro, and biomass facilities.
3. The dashed lines represent the site boundary.

FIGURE E 106.1
ENERGY TRANSFER FOR NET ZERO ENERGY PROJECTS

E 106.2 Use of Reclaimed (Recycled) and Onsite Treated Nonpotable Water for Cooling. Where approved for use by the water or wastewater utility and the Authority Having Jurisdiction, reclaimed(recycled), or on-site treated nonpotable water shall be permitted to be used for industrial and commercial cooling or air-conditioning.

E 106.3 Heating, Ventilation, and Air Conditioning Systems Commissioning. The provisions of this section apply to the commissioning of commercial and institutional HVAC systems.
E 106.3.1 Commissioning Requirements. HVAC commissioning shall be included in the design and construction processes of the project to verify compliance with this appendix and verify that the HVAC systems and components meet the owner’s project requirements. Commissioning shall be performed in accordance with this appendix by personnel trained and certified in commissioning by a nationally recognized organization. Commissioning requirements shall include the following:
(1) Owner’s project requirements.
(2) Basis of design.
(3) Commissioning measures shown in the construction documents.
(4) Commissioning plan.
(5) Functional performance.
(6) Testing.
(7) Post construction documentation and training.
(8) Commissioning report.

HVAC systems and components covered by this appendix, as well as process equipment and controls, and renewable energy systems, shall be included in the scope of the commissioning requirements.

**E 106.3.2 Owner’s Project Requirements (OPR).** The performance goals and requirements of the HVAC system shall be documented before the design phase of the project begins. This documentation shall include not less than the following:
(1) Environmental and sustainability goals.
(2) Energy efficiency goals.
(3) Indoor environmental quality requirements.
(4) Equipment and systems performance goals.
(5) Building occupant and operations and maintenance (O&M) personnel expectations.

**E 106.3.3 Basis of Design (BOD).** A written explanation of how the design of the HVAC system meets the owner’s project requirements shall be completed at the design phase of the building project and updated as necessary during the design and construction phases. The basis of design document shall cover not less than the following systems:
(1) Heating, ventilation, air conditioning (HVAC) systems and controls.
(2) Water heating systems.
(3) Renewable energy systems.

**E 106.3.4 Commissioning Plan.** A commissioning plan shall be completed to document the approach of how the project will be commissioned and shall be started during the design phase of the building project. The commissioning plan shall include not less than the following:
(1) General project information.
(2) Commissioning goals.
(3) Systems to be commissioned. Plans to test systems and components shall include at least the following information:
   (a) A detailed explanation of the original design intent.
   (b) Equipment and systems to be tested, including the extent of tests.
   (c) Functions to be tested.
   (d) Conditions under which the test shall be performed.
   (e) Measurable criteria for acceptable performance.
(4) Commissioning team information.
(5) Commissioning process activities, schedules, and responsibilities. Plans for the completion of commissioning requirements listed in Section E 106.3.5 through Section E 106.5 shall be included.

**E 106.3.5 Functional Performance Testing.** Functional performance tests shall demonstrate the correct installation and operation of each component, system, and system-to-system interface in accordance with the approved plans and specifications. Functional performance testing reports shall contain information addressing each of the building components tested, the testing methods utilized, and readings and adjustments made.

**E 106.4 Construction Documents.** Details of commissioning acceptance requirements shall be incorporated into the construction documents, including information that describes the details of the functional tests to be performed. This information shall be permitted to be integrated into the specifications for testing and air balancing, energy management and control systems, and equipment startup procedures or commissioning. It is possible that the work will be performed by a combination of the test and balance (TAB) contractor, mechanical/electrical contractor, and the energy management control system (EMCS) contractor; so applicable roles and responsibilities shall be clearly called out.

**E 106.5 Commissioning Tests.** Functional tests shall be performed on new equipment and systems installed in either new construction or retrofit applications in accordance with the mechanical code and the Authority Having Jurisdiction. The appropriate certificate of acceptance form along with each specific test shall be completed and submitted to the Authority Having Jurisdiction before a final occupancy permit can be granted.

**E 106.6 Minimum Equipment Efficiency Tables.** The minimum efficiency requirements for listed equipment shall comply with ASHRAE 90.1.

### 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/ANSI WE•Stand-2020</td>
<td>Water Efficiency and Sanitation Standard for the Built Environment</td>
<td>Water Conservation</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)
The proposed new appendix provides guidelines for achieving net zero energy and net positive energy buildings through the use of energy-efficient equipment and renewable energy systems. Net zero energy buildings combine energy efficiency and renewable energy generation to consume only as much energy as can be produced on-site through renewable resources. Although achieving net zero energy buildings requires a combination of sustainable engineering methods in order to be successful, there is a growing desire for such design and construction in both private and commercial applications.

Section E 103.0 (General Regulations) and supporting subsections address the use of renewable energy systems with appropriate design and installation requirements. Specific reference to other chapters and industry standards has been provided for solar thermal systems, geothermal energy systems, and solar photovoltaic systems. Other renewable energy systems not addressed by this appendix are required to comply with the applicable recognized standards approved by the AHJ. As an additional means of environmental consciousness, the WE-Stand was referenced to cover water efficiency and conservation. Section E 104.0 (Certification) is intended to provide users of the code with available certification agencies/programs.

The U.S. Green Building Council (USGBC) developed LEED certifications from their green building rating system, and now offer LEED Zero for verification of meeting net zero goals for carbon emissions, source energy usage, potable water usage, and zero waste.

The International Living Future Institute (ILFI) Zero Energy Certification is an international third-party performance certification based on actual performance reviewed by an auditor. This agency provides a case study platform for projects to assist and accelerate zero energy efforts.

The DOE Zero Energy Ready Home (ZERH) program is based on the comprehensive building science requirements of ENERGY STAR for Homes, along with proven Building America innovations and best practices. DOE Zero Energy Ready Homes are verified by a qualified third-party and are at least 40%-50% more energy-efficient than a typical new home.

Earth Advantage Zero Energy Certification is designed to create a standard for homes that wish to achieve a higher level of energy performance while still maintaining a sustainable approach to building. They also offer the Zero Energy Ready certification which focuses on buildings which are “ready” for adding the actual physical renewable systems in the future.

Furthermore, the provided energy efficient loading order in Section E 105.0 is necessary as it significantly reduces energy consumption of both residential and commercial buildings. This loading order is a design pathway for achieving net zero and provides the necessary decision making processes for energy efficient strategies and measures for various construction projects. Although the methodology is simple, the inclusion of the energy loading order within the recommendations of this appendix serve meaningful and effective.

Section E 106.0 (Sustainable Practices) and all subsections were gathered from the mechanical code. Such recommendations promote sustainable practices by enhancing the design and construction of mechanical systems for a positive long-term environmental impact.

Figure E 106.1 has been provided as it offers a simplified energy flow diagram for net zero applications. The diagram includes a site boundary with directional delivered and exported energy and lists the possible building needs as well as the types of onsite renewable energy use and generation.

Section E 106.2 was included as it promotes water conversation through the use of reclaimed (recycled) or onsite treated nonpotable water for industrial and commercial cooling or air-conditioning.

In order to provide comprehensive provisions for net zero applications, the Task Group decided to also include requirements for commissioning of commercial and institutional HVAC systems. The listed subsections offer provisional language pertaining to performance goals and requirements, proper documentation, written explanation or basis of design, commissioning plans, as well as functional performance and commissioning testing. Such language also correlates with the sustainable practices as depicted within the mechanical code.
COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The intent of the proposed appendix is clear to the Technical Committee. However, energy consumption and net metering are dependent upon the utility, and therefore a general appendix may not be appropriate. Additionally, the provisions may be overly restrictive, and carbon reduction may be a more suitable goal for energy efficiency. Furthermore, there should be clarification for the end user on the type of energy being addressed.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 15 NEGATIVE: 1

EXPLANATION OF NEGATIVE:
KEMPER: This proposal should be adopted. This concept and the methods of testing and verification need to be addressed in this code as an appendix guideline. This type of construction has been a goal of the State of California and many of the cost effective provisions to achieve Net Zero have already been mandated.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC Section #: Appendix E

SUBMITTER: Monte Myers
Self

RECOMMENDATION:
Accept as Submitted

Request to accept the code change proposal as submitted by this public comment.

SUBSTANTIATION:
The original proposal should have been accepted as it offers comprehensive provisions for net zero applications without being overly restrictive. The provisions align with the most current net zero certification requirements and offer additional guidance as it pertains to energy loading orders and commissioning of HVAC systems.

The original substantiation offers sufficient technical justification for accepting this appendix, and since net zero requirements are being mandated by certain states, it would be beneficial to promote net zero buildings in the USHGC. This appendix references Chapter 5 (Solar Thermal Systems), Chapter 7 (Geothermal Energy Systems), Chapter 8 (Solar PV Systems), IAPMO IS 34, and the WEStand. Not only are these renewable energy systems supported by extensive requirements throughout the USHGC, but the WEStand focuses on water efficiency and conservation.

Additionally, reference has been made to ASHRAE 90.1 for minimum efficiency requirements for listed equipment. The requirements of ASHRAE 90.1 align with the Department of Energy and further enhance the broad coverage of this appendix. The committee statement mentions that a general appendix may not be appropriate, however, a broad coverage of net zero is required since building designs drastically vary and the use of hybrid renewable energy systems may be appropriate. Dependent on the load of energy consuming equipment and design parameters, net zero buildings cannot be bound by overly restrictive requirements listed for all designs. Therefore, the general regulations and certification requirements in combination with ASHRAE 90.1 serves as the best approach to introduce net zero into the USHGC. If this appendix is not accepted, the USHGC will fall behind in strategies, approaches, and technologies associated with net zero.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 116
USHGC 2024  Section: Table 901.1

SUBMITTER: Karl Best
AHRI

RECOMMENDATION:
Revise text

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

(portion of table not shown remains unchanged)

Note: AHRI 210/240 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:
The above revisions reflect the latest updates to the AHRI standards that are referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1
Code Year: 2024 USHGC  Section #: Table 901.1
SUBMITTER: Emily Toto
ASHRAE

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

**TABLE 901.1**
**REFERRED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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<tbody>
<tr>
<td>ASHRAE 34-2019</td>
<td>Designation and Safety Classification of Refrigerants</td>
<td>Refrigerant Classifications</td>
<td>706.3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**Note:** ASHRAE 34 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:**
The above revision reflects the latest update to the ASHRAE standard that is referenced in Table 901.1.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 117
USHGC 2024  Section: Table 901.1, Table 901.2

SUBMITTER: Steven Rossi
ASME

RECOMMENDATION:
Revise text

### TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME B16.3-2016-2021</td>
<td>Malleable Iron Threaded Fittings: Classes 150 and 300</td>
<td>Fittings</td>
<td>Table 409.1</td>
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<tr>
<td>ASME B16.5-2017-2020</td>
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(portion of table not shown remains unchanged)

Note: The ASME standards 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.

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

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SUBSTANTIATION:
The above revisions reflect the latest updates to the ASME standards that are referenced in Table 901.1 and Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC   Section #: Table 901.1

SUBMITTER: Angel Guzman Rodriguez/Steven Rossi

ASME

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

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Note: The ASME standards 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 above revisions reflect the latest updates to the ASME standards that are referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 118

USHGC 2024  Section: Table 901.1

SUBMITTER: Terry Burger
ASSE

RECOMMENDATION:
Revise text

TABLE 901.1
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SUBSTANTIATION:
The above revisions reflect the latest updates to the ASSE standards that are referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.1, Table 901.2  Item #: 118
SUBMITTER: Terry Burger
ASSE  Comment #: 1
RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

TABLE 901.1
REFERENCED STANDARDS

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TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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SUBSTANTIATION:
The above revisions reflect the latest updates to the ASSE standards that are referenced in Table 901.1 and Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Item #: 119
USHGC 2024  Section: Table 901.1, Table 901.2

SUBMITTER: Steve Mawn
ASTM

RECOMMENDATION:
Revise text

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2021
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ASTM F2620-2019
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ASTM F3348-2019a
2021a
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(portion of table not shown remains unchanged)

Note: The ASTM standards 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.

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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.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
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<td>ASTM A778/A778M-</td>
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**TABLE 901.2**

STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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<td>ASTM D2672-2020a</td>
<td>Joints for IPS PVC Pipe Using Solvent Cement</td>
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<td>ASTM D2855-2020</td>
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<td>Flash Point of Liquids by Small Scale Closed-Cup Apparatus</td>
<td>Testing</td>
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(portion of table not shown remains unchanged)
Committee Statement:
The proposal is being updated to reflect the most recent edition of ASTM F876.

Total Eligible to Vote: 16

Voting Results: Affirmative: 16

Explanation of Affirmative:

Matson: This item was correct as amended at the time of the meeting but will require a Public Comment to update ASTM F3347 and ASTM F3348 as they have since been published with a revised 2022 date.

Appended Comments

Public Comment 1

Code Year: 2024 USHGC  Section #: Table 901.1, Table 901.2  Item #: 119

Submitter: Frank McConnell  ASTM

Recommendation: Accept as Modified

Request to accept the code change proposal as modified by this public comment.

Table 901.1

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Note: The ASTM standards 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.
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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.

**COMMITTEE ACTION:** ACCEPT AS AMENDED BY THE TC

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<tr>
<td>ASTM F2159-20192023a</td>
<td>Standard Specification for 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>
<td>Table 409.1, Table 703.3</td>
</tr>
<tr>
<td>ASTM F2389-20242023</td>
<td>Standard Specification for Pressure-Rated Polypropylene (PP) Piping Systems</td>
<td>Piping</td>
<td>Table 409.1, 410.12(1), Table 703.2, Table 703.3</td>
</tr>
<tr>
<td>ASTM F2620-2020a2</td>
<td>Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings</td>
<td>Joints</td>
<td>410.9(1), 410.9(3), 703.4.1.1(1), 703.4.1.1(2)</td>
</tr>
<tr>
<td>ASTM F2623-2022</td>
<td>Standard Specification for Polyethylene of Raised Temperature (PE-RT) Systems for</td>
<td>Piping</td>
<td>Table 409.1, Table 703.2</td>
</tr>
<tr>
<td>DOCUMENT NUMBER</td>
<td>DOCUMENT TITLE</td>
<td>APPLICATION</td>
<td>Table</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>ASTM F2769-2023</td>
<td>Standard Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems</td>
<td>Piping, Fitting</td>
<td>409.1, Table 703.2, Table 703.3</td>
</tr>
<tr>
<td>ASTM F3347-2023</td>
<td>Standard Specification for Metal Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing</td>
<td>Fittings</td>
<td>409.1, Table 703.3</td>
</tr>
<tr>
<td>ASTM F3348-2023</td>
<td>Standard Specification for Plastic Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing</td>
<td>Fittings</td>
<td>409.1, Table 703.3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains 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>ASTM A733-2016 (R2022)</td>
<td>Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples</td>
<td>Piping, Ferrous</td>
</tr>
<tr>
<td>ASTM D56-2022</td>
<td>Standard Test Method for Flash Point by Tag Closed Cup Tester</td>
<td>Testing</td>
</tr>
<tr>
<td>ASTM D93-2020</td>
<td>Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester</td>
<td>Testing</td>
</tr>
<tr>
<td>ASTM D635-2022</td>
<td>Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position</td>
<td>Testing</td>
</tr>
<tr>
<td>ASTM D2855-2020</td>
<td>Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets</td>
<td>Joints</td>
</tr>
<tr>
<td>ASTM D3278-2021</td>
<td>Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus</td>
<td>Testing</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**COMMITTEE STATEMENT:**
Item #119 Public comment 01 is being modified to incorporate the latest editions of ASTM F1281, ASTM F1807, ASTM F2080, ASTM F2159, and ASTM F2389 which all incorporate “building supply lines” into the scope of each of these standards.

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:**  
**AFFIRMATIVE:** 16
PUBLIC COMMENT 2

Code Year: 2024 USHGC  Section #: Table 901.1  Item #: 119
SUBMITTER: Peter Portela  
AWS  
Comment #: 2
RECOMMENDATION: Accept as Modified

Request to accept the code change proposal as modified by this public comment.

TABLE 901.1
REFERENCED STANDARDS

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

(portion of table not shown remains unchanged)

Note: AWS A5.9/A5.9M(ISO 14343) 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:
The above revision reflects the latest update to the AWS standard that is referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Item #: 120

USHGC 2024  Section: Table 901.1

SUBMITTER: Paul Olson
AWWA

RECOMMENDATION:
Revise text

### TABLE 901.1
**REFERENCED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWWA C901-2017-2020</td>
<td>Polyethylene (PE) Pressure Pipe and Tubing, 3/4 In. (19 mm) Through 3 In. (76 mm), for Water Service</td>
<td>Piping</td>
<td>Table 409.1, Table 703.2</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**Note:** AWWA C901 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:**
The above revision reflects the latest update to the AWWA standard that is referenced in Table 901.1.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16

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**Appended Comments**

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**PUBLIC COMMENT 1**

**Code Year:** 2024 USHGC  **Section #:** Table 901.1

**SUBMITTER:** Paul Olson
AWWA

**RECOMMENDATION:**
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWWA C110/A21.10-2021</td>
<td>Ductile-Iron and Gray-Iron Fittings</td>
<td>Fittings</td>
<td>Table 409.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: AWWA C110/A21.10 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:
The above revision reflects the latest update to the AWWA standard that is referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 121

USHGC 2024  Section: Table 901.2

SUBMITTER: Ed Tsang
BSI

RECOMMENDATION:
Revise text

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the BSI standards that are referenced in Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.2
SUBMITTER: Tom Wilkins
BS

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
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<th>APPLICATION</th>
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</thead>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The above revision reflects the latest update to the BS standard that is referenced in Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
**TABLE 901.1**
**REFERENCED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA B137.1-2017 2020</td>
<td>Polyethylene (PE) Pipe, Tubing, and Fittings for Cold-Water Pressure Services</td>
<td>Piping</td>
<td>Table 409.1, Table 703.2, Table 703.3</td>
</tr>
<tr>
<td>CSA B137.2-2017 2020</td>
<td>Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications</td>
<td>Fittings</td>
<td>Table 409.1</td>
</tr>
<tr>
<td>CSA B137.3-2017 2020</td>
<td>Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications</td>
<td>Piping, Fittings</td>
<td>Table 409.1</td>
</tr>
<tr>
<td>CSA B137.5-2017 2020</td>
<td>Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications</td>
<td>Piping</td>
<td>Table 409.1, Table 703.2, Table 703.3</td>
</tr>
<tr>
<td>CSA B137.6-2017 2020</td>
<td>Chlorinated Polyvinylchloride (CPVC) Pipe, Tubing, and Fittings for Hot- and Cold-Water Distribution Systems</td>
<td>Piping, Fittings</td>
<td>Table 409.1</td>
</tr>
<tr>
<td>CSA B137.9-2017 2020</td>
<td>Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure-Pipe Systems</td>
<td>Piping</td>
<td>Table 409.1</td>
</tr>
<tr>
<td>CSA B137.10-2017 2020</td>
<td>Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Composite Pressure-Pipe Systems</td>
<td>Piping</td>
<td>Table 409.1</td>
</tr>
<tr>
<td>CSA B137.11-2017 2020</td>
<td>Polypolpene (PP-R &amp; PP-RCT) Pipe and Fittings for Pressure Applications</td>
<td>Piping</td>
<td>Table 409.1, 410.10(1), Table 703.2, Table 703.3</td>
</tr>
<tr>
<td>CSA B137.18-2017 2020</td>
<td>Polyethylene of Raised Temperature Resistance (PE-RT) Tubing Systems for Pressure Applications</td>
<td>Piping, Fittings</td>
<td>Table 409.1, Table 703.2, Table 703.3</td>
</tr>
</tbody>
</table>
TABLE 901.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the CSA standards that are referenced in Table 901.1 and Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 15 NEGATIVE: 1

EXPLANATION OF AFFIRMATIVE:
HALDIMAN: Lance MacNevin is correct; the complete series is already included.
MACNEVIN: CSA C448.1 and C448.2 should be removed from this table as these are sub-sections of C448, which is listed in the table correctly. This change needs to be addressed by the Technical Correlating Committee.
SMITH: I agree with Lance MacNevin.

EXPLANATION OF NEGATIVE:
MATSON: Item #090 removed the specific references to CSA C448.1 and CSA C448.2 from this table, so this item should be rejected and updated in Public Comment.
The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the Technical Committee. The TCC has the authority to choose between alternative text recommended by the Technical Committee, but only as necessary for correlation, consistency, and the correction of errors and omissions in accordance with Section 3.6 of the Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

The action taken by the USHGC TC to “accept as submitted” Item # 090 Table 901.1 (Referenced Standards) resulted in a conflict with the action taken by the USHGC TC to “accept as submitted” Item # 122 Table 901.1 (Referenced Standards) regarding references to CSA C448.1, CSA C448.2, and CSA/IGSHPA C448. The action taken for Item # 122 was the latest action and therefore prevailed. In order to correlate the language, the Technical Correlating Committee proposed the following modifications to the USHGC:

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI/CSA/IGSHPA C448 Series-2016 (R2021)</td>
<td>Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings</td>
<td>Miscellaneous Ground-Source Heat Pumps</td>
<td>Table 703.2, 708.7, 709.1, 710.6, 710.6.2, 715.4</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

TCC ACTION: ACCEPT AS SUBMITTED

TCC STATEMENT:
The language in USHGC Item # 122, Table 901.1 (Referenced Standards) is being revised to remove CSA C448.1 and CSA C448.2 as they are no longer referenced in the body of the code and are already part of the ANSI/CSA/IGSHPA C448 standard. The action correlates with the language approved by the USHGC TC for Item # 090, Table 901.1 (Referenced Standards).

The action moves forward as approved by the TCC and supersedes the recommendation from the USHGC TC for actions taken on Table 901.1 (Referenced Standards) regarding references to CSA C448.1, CSA C448.2, and CSA/IGSHPA C448.

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.2  Item #: 122

SUBMITTER: Lauro Pilla / Nikki Kidd  CSA

RECOMMENDATION: Accept as Modified
Request to accept the code change proposal \textit{as modified} by this public comment.

\begin{center}
\begin{tabular}{|l|l|l|}
\hline
\textbf{DOCUMENT NUMBER} & \textbf{DOCUMENT TITLE} & \textbf{APPLICATION} \\
\hline
2022/CSA 6.10-2015 (R2020)-2022 &  & \\
\hline
\end{tabular}
\end{center}

(portion of table not shown remains unchanged)

\textbf{SUBSTANTIATION:}
The above revision reflects the latest update to the CSA standard that is referenced in Table 901.2.

\textbf{COMMITTEE ACTION:} ACCEPT AS SUBMITTED

\textbf{TOTAL ELIGIBLE TO VOTE:} 16

\textbf{VOTING RESULTS:} AFFIRMATIVE: 16
Proposals

Item #: 123

USHGC 2024  Section: Table 901.1

SUBMITTER: Terry Burger
IAPMO

RECOMMENDATION:
Revise text

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO PS 117-2019-2021</td>
<td>Press Connections</td>
<td>Fittings</td>
<td>Table 409.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: IAPMO PS 117 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:
The above revision reflects the latest update to the IAPMO standard that is referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO/ANSI/CAN Z1117-PS-417-2024-2022</td>
<td>Press Connections</td>
<td>Fittings</td>
<td>Table 409.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

COMMITTEE STATEMENT:
The amendment updates IAPMO PS 117-2021 to IAPMO/ANSI/CAN Z1117-2022 to show the latest edition of the standard.

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments
PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.1  Item #: 123
SUBMITTER: Terry Burger  ASSE  Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

<table>
<thead>
<tr>
<th>TABLE 901.1</th>
<th>REFERENCED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD NUMBER</td>
<td>STANDARD TITLE</td>
</tr>
<tr>
<td>IAPMO/ANSI H1001.1-2021</td>
<td>Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems</td>
</tr>
<tr>
<td>IAPMO/ANSI/CAN Z1117-2022</td>
<td>Standard for Press Connections</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: IAPMO/ANSI H1001.1 and IAPMO/ANSI/CAN Z1117 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 above revisions reflect the latest updates to the IAPMO standards that are referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the Technical Committee. The TCC has the authority to choose between alternative text recommended by the Technical Committee, but only as necessary for correlation, consistency, and the correction of errors and omissions in accordance with Section 3.6 of the Regulations Governing Consensus Development of the Uniform Solar, Hydronics & Geothermal and Swimming Pool, Spa & Hot Tub Codes.

The action taken by the USHGC TC to “accept as submitted” Item # 123 Comment 1 resulted in a conflict with the action taken by the USPSHTC TC to “accept as submitted” Item # 092 Comment 1. In order to correlate the language, the Technical Correlating Committee proposed the following modifications to the USHGC:

<table>
<thead>
<tr>
<th>TABLE 409.1</th>
<th>MATERIALS FOR HYDRONIC AND SOLAR THERMAL SYSTEM PIPING, TUBING, AND FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATERIAL</td>
<td>STANDARDS</td>
</tr>
<tr>
<td>Copper and Copper Alloys</td>
<td>PIPING/TUBING</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)
TCC ACTION: ACCEPT AS SUBMITTED

TCC STATEMENT:
USHGC Table 409.1 (Materials for Hydronic and Solar Thermal System Piping, Tubing, and Fittings) is being revised to correlate with USPSHTC Table 308.1 (Materials for Building Supply, Water Distribution, and Air Circulation System Piping and Fittings) regarding the referenced material, "Copper and Copper Alloys."

The action moves forward as approved by the TCC and updates the material reference from "Copper/Copper Alloy" to "Copper and Copper Alloys" in USHGC Table 308.1 (Materials for Building Supply, Water Distribution, and Air Circulation System Piping and Fittings).
Proposals

Item #: 125
USHGC 2024  Section: Table 901.2

SUBMITTER: Anasthasie Sainvilus
IEEE

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>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 1562-2007-2021</td>
<td>Array and Battery Sizing in of Stand-Alone Photovoltaic (PV) Systems</td>
<td>Array, Battery, Photovoltaic</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the IEEE standards that are referenced in Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.2  Item #: 125
SUBMITTER: Anasthasie Sainvilus
IEEE  Comment #: 1

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

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

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
</table>

(portion of table not shown remains unchanged)

**SUBSTANTIATION:**
The above revision reflects the latest update to the IEEE standard that is referenced in Table 901.2.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16

PUBLIC COMMENT 2

**Code Year:** 2024 USHGC  **Section #:** Table 901.2  **Item #:** 125  **Comment #:** 2

**SUBMITTER:** Casey Granata  NEMA

**RECOMMENDATION:**
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

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

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
</table>

(portion of table not shown remains unchanged)

**SUBSTANTIATION:**
The above revision reflects the latest update to the NEMA standard that is referenced in Table 901.2.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 126

USHGC 2024  Section: Table 901.2

SUBMITTER: Alex Ing
NFPA

RECOMMENDATION:
Revise text

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
NFPA 54 has been revised since the last edition of the USHGC and we are requesting that it is updated to the latest edition year. The full title of NFPA 274 is not currently used, and we request that is updated accordingly.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS:  AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.1

SUBMITTER: Alexander Ing
NFPA

RECOMMENDATION:
Accept as Modified
Request to accept the code change proposal as modified by this public comment.

### TABLE 901.1
**REFERENCED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NFPA 70-2023</td>
<td>National Electrical Code</td>
<td>Miscellaneous</td>
<td>304.4.5, 315.1, 315.2, 801.1, 804.1, 806.1.3(4)(d), 806.4, 807.2, 810.1.3, 812.1, Table 812.1(2), 812.2.1, 812.4, 812.5, 812.6, 812.7.3(8), 812.7.3(11), 812.7.3(12), 812.8, 818.1, 818.1.4, 818.2, 819.1, 819.1.2, 819.1.3(1), 819.1.4, Table 819.1, 820.1.9(3), 820.2, 820.2.2, 820.3, 825.1, 826.1, 829.2(2), 829.4, B 104.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**Note:** NFPA 70 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:**
The above revision reflects the latest update to the NFPA standard that is referenced in Table 901.1.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 16

**VOTING RESULTS:** AFFIRMATIVE: 16
Proposals

Item #: 127
USHGC 2024  Section: Table 901.1, Table 901.2

SUBMITTER: Jeremy Brown
NSF

RECOMMENDATION: Revise text

| TABLE 901.1  
| REFERENCED STANDARDS |
| STANDARD       | STANDARD TITLE                                                                 | APPLICATION       | REFERENCED SECTION |
| NUMBER         |                                                                                   |                   |                   |
| NSF/ANSI/CAN 60-2019-2021 | Drinking Water Treatment Chemicals - Health Effects  | Backfill          | 710.6.1           |
| NSF/ANSI/CAN 61-2019-2021 | Drinking Water System Components - Health Effects | Miscellaneous     | 501.5.4           |
| NSF/ANSI 358-1-2017 | Polyethylene Pipe and Fittings for Water-Based Ground- Source “Geothermal” Heat Pump Systems | Piping, Fittings | Table 409.1, Table 703.2, Table 703.3 |
| NSF/ANSI 358-2-2017 | Polypropylene Pipe and Fittings for Water-Based Ground- Source “Geothermal” Heat Pump Systems | Piping, Fittings | Table 409.1, Table 703.2, Table 703.3 |
| NSF/ANSI 358-3-2016-2021 | Cross-Linked Polyethylene (PEX) Pipe and Fittings for Water- Based Ground-Source (Geothermal) Heat Pump Systems | Piping, Fittings | Table 409.1, Table 703.2, Table 703.3 |
| NSF/ANSI 358-4-2018 | Polyethylene of Raised Temperature (PE-RT) Tubing and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems | Piping, Fittings | Table 703.2, Table 703.3 |

(portion of table not shown remains unchanged)

**Note:** The NSF standards 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.

| TABLE 901.2  
| STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES |
| DOCUMENT       | DOCUMENT TITLE                                                                 | APPLICATION       |
| NUMBER         |                                                                                   |                   |

(portion of table not shown remains unchanged)
SUBSTANTIATION:
The above revisions reflect the latest updates to the NSF standards that are referenced in Table 901.1 and Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.1, Table 901.2  Item #: 127  Comment #: 1

SUBMITTER: Jeremy Brown  NSF

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF/ANSI/CAN 61-2024-2022</td>
<td>Drinking Water System Components - Health Effects</td>
<td>Miscellaneous</td>
<td>501.5.4</td>
</tr>
<tr>
<td>NSF/ANSI 358-4-2018 2022</td>
<td>Polyethylene of Raised Temperature (PE-RT) Tubing and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems</td>
<td>Piping, Fittings</td>
<td>Table 703.2, Table 703.3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: NSF/ANSI/CAN 61 and NSF/ANSI 358-4 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.

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF/ANSI 14-2020 2022</td>
<td>Plastics Piping System Components and Related Materials</td>
<td>Piping, Plastic</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the NSF standards that are referenced in Table 901.1 and Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Proposals

Item #: 128
USHGC 2024  Section: Table 901.1, Table 901.2

SUBMITTER: John Taecker
UL LLC

RECOMMENDATION:
Revise text

### 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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</thead>
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<tr>
<td>UL 778-2016</td>
<td>Motor-Operated Water Pumps (with revisions through January 17, 2019-June 29, 2021)</td>
<td>Pumps</td>
<td>308.1.1, 310.1</td>
</tr>
<tr>
<td>UL 1699B-2018</td>
<td>Photovoltaic (PV) DC Arc-Fault Circuit Protection (with revisions through May 18, 2021)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 1741-2019</td>
<td>Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources (with revisions through February 15, 2018)</td>
<td>Electrical</td>
<td>Table 802.2.1, 828.1</td>
</tr>
<tr>
<td>UL 2703-2015</td>
<td>Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels (with revisions through December 16, 2019-March 24, 2021)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 3703-2015</td>
<td>Solar Trackers (with revisions through April 7, 2020)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 4703-2014</td>
<td>Photovoltaic Wire (with revision through August 11, 2020)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 6703-2014</td>
<td>Connectors for Use in Photovoltaic Systems (with revisions through December 22, 2017-June 10, 2021)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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<tr>
<td>UL 61730-1-2017</td>
<td>Photovoltaic (PV) Module Safety Qualification - Part 1: Requirements for Construction (with revisions through April 30, 2020)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 61730-2-2017</td>
<td>Photovoltaic (PV) Module Safety Qualification - Part 2: Requirements for Testing (with revisions through November 20, 2020)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
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</tbody>
</table>

(portion of table not shown remains unchanged)

Note: The UL standards 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.
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>UL 174-2004</td>
<td>Household Electric Storage Tank Water Heaters (with revisions through December 16, 2021)</td>
<td>Appliances</td>
</tr>
<tr>
<td>UL 873-2007</td>
<td>Temperature-Indicating and -Regulating Equipment (with revisions through February 6, 2015)</td>
<td>Electrical</td>
</tr>
<tr>
<td>UL 916-2015</td>
<td>Energy Management Equipment (with revisions through October 21, 2021)</td>
<td>Electrical</td>
</tr>
<tr>
<td>UL 60730-1 2016</td>
<td>Automatic Electrical Controls – Part 1: General Requirements (with revisions through October 18, 2021)</td>
<td>Electrical</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the UL standards that are referenced in Table 901.1 and Table 901.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16

Appended Comments

PUBLIC COMMENT 1

Code Year: 2024 USHGC  Section #: Table 901.1  Item #: 128

SUBMITTER: John Taecker  UL LLC  Comment #: 1

RECOMMENDATION:
Accept as Modified

Request to accept the code change proposal as modified by this public comment.

TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1741-2021</td>
<td>Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources (with revisions through October 18, 2022)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
<tr>
<td>UL 1995-2016-2022</td>
<td>Heating and Cooling Equipment (with revisions through August 17, 2018)</td>
<td>Heat Pumps</td>
<td>407.5, 706.1</td>
</tr>
<tr>
<td>UL 2523-2009</td>
<td>Solid Fuel-Fired Hydronic Heating Appliances, Water Heaters, and Boilers (with revisions through March 16, 2018-October 20, 2022)</td>
<td>Fuel Gas, Appliances</td>
<td>Table 403.2</td>
</tr>
<tr>
<td>UL 2989-2016-2022</td>
<td>Outline of Investigation for Tracer Wire</td>
<td>Tracer Wire</td>
<td>707.17.8</td>
</tr>
<tr>
<td>UL 61730-1-2017-2022</td>
<td>Photovoltaic (PV) Module Safety Qualification - Part 1: Requirements for Construction (with revisions through April 30, 2020)</td>
<td>Electrical</td>
<td>Table 802.2.1</td>
</tr>
</tbody>
</table>
Note: UL 1741, UL 1995, UL 2523, UL 60335-2-40, UL 61730-1, and UL 61730-2 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.

Note: UL 2989 does not 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 above revisions reflect the latest updates to the UL standards that are referenced in Table 901.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 16

VOTING RESULTS: AFFIRMATIVE: 16
Technical Correlating Committee Report for USHGC/USPSHTC
**TCC ITEM # 001**

2024 UNIFORM SOLAR, HYDRONICS & GEOTHERMAL CODE

ITEM # 119 COMMENT 1

2024 UNIFORM SWIMMING POOL, SPA & HOT TUB CODE

ITEM # 088 COMMENT 1

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>ASTM D2855-2020</td>
<td>Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets</td>
<td>Joints</td>
</tr>
</tbody>
</table>

TABLE 1001.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D2855-2020</td>
<td>Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets</td>
<td>Joints</td>
</tr>
</tbody>
</table>

X | Accept recommendation as submitted. | No action needed.

**Substantiation:** The standard title for ASTM D2855, as shown in USPSHTC Item #088 Comment 1 Table 1001.2 (Standards, Publications, Practices, and Guides), is being revised to correlate with the latest edition of the standard. This action correlates with the language approved by the USHGC TC for Item #119 Comment 1, Table 901.2 (Standards, Publications, Practices, and Guides).

The following is provided for informational purposes only:

**The substantiation provided for Item # 119 Comment 1 of the USHGC is as follows:**
The above revisions reflect the latest updates to the ASTM standards that are referenced in Table 901.1 and Table 901.2.

**The Committee Statement provided for amending Item # 119 Comment 1 by the USHGC TC is as follows:**
Item #119 Public comment 01 is being modified to incorporate the latest editions of ASTM F1281, ASTM F1807, ASTM F2080, ASTM F2159, and ASTM F2389 which all incorporate "building supply lines" into the scope of each of these standards.

**The substantiation provided for Item # 088 Comment 1 of the USPSHTC is as follows:**
The above revisions reflect the latest updates to the ASTM standards that are referenced in Table 1001.1 and Table 1001.2.
Accept recommendation as submitted. No action needed.

Substantiation: The standard edition for AWS A5.9/A5.9M, as shown in USPSHTC Item #088 Comment 2 Table 1001.1 (Referenced Standards), is being revised to correlate with the latest publication date of the standard. This action correlates with the language approved by the USHGC TC for Item #119 Comment 2, Table 901.1 (Referenced Standards).

The following is provided for informational purposes only:

The substantiation provided for Item # 119 Comment 2 of the USHGC is as follows:
*The above revision reflects the latest update to the AWS standard that is referenced in Table 901.1.*

The substantiation provided for Item # 088 Comment 2 of the USPSHTC is as follows:
*The above revision reflects the latest update to the AWS standard that is referenced in Table 1001.1.*
TCC ITEM # 003

2024 UNIFORM SOLAR, HYDRONICS & GEOTHERMAL CODE

ITEM # 123 COMMENT 1

TABLE 901.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO/ANSI/CAN Z1117-2022</td>
<td>Standard for Press Connections</td>
<td>Fittings</td>
<td>Table 409.1</td>
</tr>
</tbody>
</table>

2024 UNIFORM SWIMMING POOL, SPA & HOT TUB CODE

ITEM # 092 COMMENT 1

TABLE 1001.1
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO/ANSI/CAN Z1117 PS 117 - 2022</td>
<td>Standard for Press Connections</td>
<td>Fittings</td>
<td>Table 308.1</td>
</tr>
</tbody>
</table>

TABLE 409.1
MATERIALS FOR HYDRONIC AND SOLAR THERMAL SYSTEM, PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>ASTM A269, ASTM A312, ASTM A554, ASTM A778, ASTM F1476, ASTM F1548, ASTM F3226, IAPMO IGC 353, IAPMO/ANSI/CAN Z1117</td>
</tr>
</tbody>
</table>

TABLE 308.1
MATERIALS FOR BUILDING SUPPLY, WATER DISTRIBUTION, AND CIRCULATION SYSTEM PIPING AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>BUILDING SUPPLY PIPING AND FITTINGS</th>
<th>WATER DISTRIBUTION PIPE AND FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper and Copper Alloys</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Accept recommendation as submitted.

No action needed.

Substantiation: The references to the IAPMO PS 117 standard, as shown in USPSHTC Item #092 Comment 1 Table 308.1 (Materials for Building Supply, Water Distribution and Circulation System Piping and Fittings) and Table 1001.1 (Referenced Standards), are being updated to correlate with the latest published edition of the standard as IAPMO/ANSI/CAN Z1117 supersedes IAPMO PS 117. This action correlates with the language approved by the USHGC TC for Item #123 Comment 1, Table 901.1 (Referenced Standards). Additionally, the reference to “Copper/Copper Alloy” in USHGC Table 409.1 (Materials for Hydronic and Solar Thermal System, Piping, Tubing, and Fittings) is being updated to “Copper and Copper Alloys.”

The following is provided for informational purposes only:

The substantiation provided for Item # 123 Comment 1 of the USHGC is as follows:
The above revisions reflect the latest updates to the IAPMO standards that are referenced in Table 901.1.

The substantiation provided for Item # 092 Comment 1 of the USPSHTC is as follows:
The above revisions reflect the latest updates to the IAPMO standards that are referenced in Table 1001.1 and Table 1001.2.
### TABLE 505.2
**WATER CHEMISTRY**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ACCEPTABLE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium hardness</td>
<td>200 – 400 parts per million (ppm)</td>
</tr>
</tbody>
</table>

### TABLE 508.1
**WATER CHEMISTRY**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ACCEPTABLE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium hardness</td>
<td>200 – 400 parts per million (ppm) (pools)</td>
</tr>
<tr>
<td></td>
<td>100 – 200 ppm (spas and hot tubes)</td>
</tr>
</tbody>
</table>

**Notes:**
1,3 (remaining text unchanged)
4 For bodies of water where the temperature is maintained below 90°F (32.2°C).
5 For bodies of water where the temperature is maintained above 90°F (32.2°C).

| Accept recommendation as submitted. | X | No action needed. |

**Substantiation:** No action is needed by the TCC for USPSHTC Item # 044 Comment 1. The TCC agrees with the action taken by the USPSHTC TC to “accept as submitted” the revised acceptable ranges for calcium hardness in USPSHTC Table 508.1 (Water Chemistry).

The following is provided for informational purposes only:

**The substantiation provided for Item # 044 Comment 1 of the USPSHTC is as follows:**
Calcium hardness of 200 - 400 ppm is preferred for proper calcium carbonate saturation and for avoiding soft-water scale when other water parameters are near their nominal levels. For venues, such as spas and hot tubs where the water temperatures greater than 90°F, the range should be 100 to 200 ppm. Too much calcium causes cloudiness and scale formation. It also reduces the effectiveness of disinfectants. In higher water temperatures, less calcium is able to stay dissolved. Scale on the pipes or coils acts as an insulator, slowing heat transfer. This makes it more expensive to heat the water. Over time, thick scale will cause a heater to fail.
Dear USHGC-USPSHTC Technical Correlating Committee Members:

Attached are the final ballot results for the committee recommendations as a result of the actions taken during your recent meeting.

7 Members eligible to Vote
All ballots were received by the final closing date of August 4, 2023
(See attached voting results for details)

There are two criteria necessary to pass the letter ballot for each item as follows:
1. The number of affirmative votes needed for each item to pass is ¾ affirmative.
2. In all cases, an affirmative vote of at least a simple majority of the total members eligible to vote is required.

7 Members eligible to vote – 0 not returned – 0 abstentions = 7 x ¾ = 5.25 or 6 affirmative votes
7 Members eligible to vote ÷ 2 = 3.5 or 4

The ballot results on all committee actions passed.

Thank you for your willingness to participate in this Committee. If you have any questions, please contact me at (909) 218-8126 or email at taylor.duran@iapmo.org

Best Regards,

Taylor Duran
## 2023 USHGC•USPSHTC TCC FINAL BALLOT RESULTS

<table>
<thead>
<tr>
<th>Ballot Name: TCC Item # 001 – July 2023</th>
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<td><strong>Total Votes:</strong></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td><strong>Vote Summary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Option</strong></td>
<td><strong>Count</strong></td>
<td><strong>Percent</strong></td>
</tr>
<tr>
<td>AFFIRMATIVE</td>
<td>7</td>
<td>100%</td>
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<td>0</td>
<td>0%</td>
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<td>ABSTAIN w/comment</td>
<td>0</td>
<td></td>
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<tr>
<td><strong>Voter Name</strong></td>
<td><strong>Vote</strong></td>
<td><strong>Voter Name</strong></td>
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<tr>
<td>Osinski, Alison</td>
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<td>MacNevin, Lance</td>
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<tr>
<td>Murray, Edmond</td>
<td>AFFIRMATIVE</td>
<td>Majerowicz, James</td>
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<tr>
<td>Rodio, Arnold</td>
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<td>Matson, Jeff</td>
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<td>Cudahy, Michael</td>
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<td>AFFIRMATIVE</td>
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<td>100%</td>
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<td>NEGATIVE w/comment</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>ABSTAIN w/comment</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Voter Name</strong></td>
<td><strong>Vote</strong></td>
<td><strong>Voter Name</strong></td>
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<tr>
<td>Osinski, Alison</td>
<td>AFFIRMATIVE</td>
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<table>
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Task Group Reports
Geothermal Energy Systems Task Group Report
Geothermal Energy Systems Task Group Report

Task Group Members:
Jeff Persons (Chair)
Lance MacNevin
James Majerowicz
Roshan Revankar
Cary Smith

Representation:
Self
Plastics Pipe Institute
Plumbers Local 130, UA
Self
Sound Geothermal Corporation

During the Uniform Solar, Hydronics & Geothermal Code Technical Committee (USHGC TC) Meeting on June 21, 2022, the USHGC TC requested that the Geothermal Energy Systems Task Group reconvene to review their respective proposals, revise current definitions pertaining to these systems, and address Uniform Mechanical Code correlation items to generate public comments for Technical Committee consideration.

The scope of the Geothermal Energy Systems Task Group, as approved by the USHGC TC, was to address district systems and revise current provisions to update and comply with requirements from other industry standards.

The Task Group reviewed their proposals published in the 2022 USHGC Report on Proposals affecting Chapter 2 (Definitions) and Chapter 7 (Geothermal Energy Systems) and generated recommendations in the form of public comments for Technical Committee consideration. Following the USHGC TC Meeting on June 21, 2022, three meetings were conducted to complete this review and discussion.

During the first meeting, the Task Group focused on reviewing proposals affecting Part I (General), Part II (Closed-Loop Systems), Part III (Open-Loop Systems), and Part IV (Direct Exchange Systems) of Chapter 7. This also included review of correlation items with the Uniform Mechanical Code and resulted in recommendations to further revise the overall applicability of Chapter 7, remove a material standard for PEX piping an fittings, revise requirements and exceptions for shutoff valves on equipment and appliances, update and reorganize ground-heat exchanger installation practices and minimum setbacks, remove thickness requirements for metallic detectable tape, and revise the applicability of Part III (Open-Loop Systems).

The second meeting then concentrated on proposals pertaining to Part V (Ambient Temperature Loops Geothermal) and review of negative comments submitted on these items. From this discussion, photovoltaic thermal systems (PVT) were added to the list of thermal resources which may be coupled with ambient temperature loop systems to improve thermal and electrical efficiency. Overall, the Task Group completed a comprehensive review of Part V in its entirety and determined that no other revisions were necessary.

The final meeting focused on terminology pertaining to geothermal energy systems and ambient temperature loops. The list of revised and new terminology was organized into four categories: general, closed-loop systems, open-loop systems, and ambient temperature loops. As geothermal energy systems are an extension of hydronic systems, all terminology for geothermal energy system types were relocated under the primary definition of “hydronic system.” The Task Group also generated new definitions to provide additional clarity on terms used within their recommendations.

Upon completion of the final Task Group meeting, 16 public comments were generated and submitted to the USHGC TC for consideration during the May 16, 2023 USHGC Technical Committee Meeting.
SECTION #: 210.0

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

210.0  - H -
Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

    Hydronic System, Geothermal Closed-Loop. A hydronic system that uses a captive fluid to recirculate between one or more heat exchangers submerged in a body of water or buried in the ground, fluidly coupled to one or more heat exchangers or heat pumps serving one or more conditioned spaces or thermal storage vessels.

SUBSTANTIATION:

The Geothermal Energy Systems Task Group is aware of the recommendation submitted by the Hydronics Systems Task Group which provides a clear definition for “closed-loop hydronic system” and wishes to further align with the intent to relocate all hydronic systems types under the main definition for “hydronic system.”

As the definition for “close-loop system” is being revised to “closed-loop hydronic system,” a definition for “geothermal closed-loop hydronic system” is needed to address geothermal systems that fall under this category. As geothermal systems are an extension, or type, of hydronic systems, it is logical and appropriate to relocate the definition as proposed. The provided terminology is descriptive and clearly dictates that a geothermal closed-loop system is a type of hydronic system that is submerged and uses a captive fluid for heat transfer.

SECTION #: 209.0

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

209.0  – G –
Groundwater. Water that exists beneath the earth’s surface which is differentiated from surface water in that it is not exposed to the atmosphere.

SUBSTANTIATION:

The existing definition for “groundwater” is vague and may lead to misinterpretation as not all water beneath the earth’s surface is considered groundwater. For this reason, language has been added to make this distinction and clarify that groundwater is water beneath the earth’s surface and is not exposed to the atmosphere.

SECTION #: 210.0, 217.0

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

217.0  - O -
Open-Loop System. A system where the fluid is enclosed in a piping system that is vented to the atmosphere.
Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

**Hydronic System, Geothermal Open-Loop.** A hydronic system that derives its source of fluid heat exchange from surface water, ground water, or commercial/industrial process water/fluid. After its use, the heat exchange fluid is discharged back to its source or to the environment.

**SUBSTANTIATION:**

In conjunction with the recommendation provided by the Geothermal Energy Systems Task Group for Item #007, the intent of this public comment is to relocate all hydronic system types under the main definition for "hydronic system." As geothermal systems are an extension, or type, of hydronic systems, it is logical and appropriate to relocate the definition as proposed. As the recommendation by the Hydronics Systems Task Group in Item #007 essentially removes or replaces the definition for "closed-loop system," the definition for "open-loop system" should also be removed.

The provided terminology clarifies that a geothermal open-loop system is a type of hydronic system, dictates sources for heat transfer fluids, and describes where the heat transfer fluid is discharged after use. The inclusion of this definition is necessary as it offers a better understanding of such systems when interpreting and implementing requirements laid out in Part III (Open-Loop Systems) of Chapter 7 (Geothermal Energy Systems).

**SECTION #: 701.1, 701.1.3**

**RECOMMENDATION:**

Request to replace the code change proposal by this public comment.

**CHAPTER 7**

**GEOTHERMAL ENERGY SYSTEMS AND DISTRICT GEOTHERMAL LOOPS**

**Part I – General.**

**701.0 General.**

**701.1 Applicability.** Part I of 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.

Part I through Part V of this chapter shall apply to geothermal energy systems and district systems that circulate ground-ambient-temperature water, conditioned water, or heat transfer fluid, to be used in end-use buildings as a thermal source or sink via water source heat pump or reversing chiller. The systems shall operate to permit independent and bi-directional heating and cooling for comfort and water heating such as, but not limited to, building systems with ground coupled district loops, including ambient temperature loops (ATL), a ground-heat exchanger, submerged heat exchanger using water-based fluid as a heat transfer medium, or groundwater (well), or such local energy resources to the advantage of the district. Central district auxiliary components shall add or reject heat to benefit district ability to reduce both power consumption and demand combined with energy sharing.

The regulations of this chapter shall govern the construction, location, and installation of ground temperature thermal distribution districts from 100 percent geothermal energy systems to multiple hybrid district systems, including systems which utilize multiple hybrid district systems and components.
701.1.3 Indoor Piping. Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Section 703.5 and Chapter 4.

SUBSTANTIATION:
Section 701.1 (Applicability) is being revised to provide insight into the various parts of Chapter 7 pertaining to general requirements, open-loop systems, closed-loop systems, DX systems, and now ambient temperature loops. The addition of geothermal district systems supports advanced thermal distribution networks and provides the code with the necessary requirements for large scale renewable energy systems. The second paragraph has been revised from the original proposal to also include the phrase “conditioned water or heat transfer fluid.” This new phrasing now addresses geothermal energy systems and district systems that circulate fluids other than just ground-ambient temperature water. The third paragraph of Section 701.1 has also been further revised to address systems that utilize multiple hybrid district systems and components. Furthermore, the language pertaining to indoor piping, fittings, and accessories has been moved from the applicability to Section 701.1.3 (Indoor Piping) as this allows for proper flow of requirements.

SECTION #: 221.0

RECOMMENDATION:
Request to replace the code change proposal by this public comment.

221.0 - S -
Submerged Heat Exchanger. A closed-loop heat exchanger submerged in water or a fluid. Some examples include, but are not limited to, lake or pond heat exchangers, sanitary waste heat recovery systems, downhole heat exchangers, and standing column well heat exchangers.

SUBSTANTIATION:
The term “submerged heat exchanger” is used throughout Chapter 7 (Geothermal Energy Systems) and requires an appropriate definition to provide clarity for users of the code. The provided definition offers both a clear depiction of this type of heat exchanger as well as several examples. It was necessary to clarify that these heat exchangers are submerged in water or fluid since there exists various applications, some of which include heat recovery from fluids other than water. As heat recovery applications expand, it is beneficial to be inclusive of emerging technologies which may be utilized.

SECTION #: Table 703.2, Table 703.3

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.

TABLE 703.2
PLASTIC GROUND SOURCE LOOP PIPING

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<th>MATERIAL</th>
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TABLE 703.3  
GROUND SOURCE LOOP PIPE FITTINGS

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(portion of table not shown remains unchanged)

**SUBSTANTIATION:**
ASTM F3253 is being removed as this standard is applicable to oxygen barrier crosslinked polyethylene (PEX) tubing which is not used in geothermal applications. Since this standard is not applicable to geothermal ground-loop system piping, there is no practical reason to include it within Table 703.2 (Plastic Ground Source Loop Piping) or Table 703.3 (Ground Source Loop Pipe Fittings).

As stated in the scope of ASTM F3253, “This specification covers requirements, test methods, and marking requirements for crosslinked polyethylene (PEX) tubing with a polymeric oxygen barrier layer, made in one standard dimension ratio (SDR 9), and distribution system components intended for hydronic heating and cooling applications up to and including a maximum working temperature of 200 °F (93 °C).”

**SECTION #:** 209.0, 705.6

**RECOMMENDATION:**
Request to replace the code change proposal by this public comment.

**705.0 Valves.**

**705.6 Equipment and Appliances.** Shutoff valves shall be installed as a means of isolating on connections to mechanical equipment and appliances.  
**Exception:** Shutoff valves shall not be required for individual geothermal ground-loops.

**209.0 - G - Geothermal Ground-Loop.** A conduit for a fluid, such as water or a water-based antifreeze solution, used to create a heat convection circuit that serves as a heat sink, source, or storage device. A single, closed continuous loop of pipe that is typically made of an approved substance such as polyethylene or polypropylene. The pipe is placed in the ground horizontally, vertically, or at an angle by either drilling or trenching. Ground loop(s) may be a single loop, or a collection of loops connected in series or parallel.

**SUBSTANTIATION:**
Based on the committee statement provided for rejection of Item #082 during the proposal stage, the Geothermal Energy Systems Task Group generated a recommendation which updates Section 705.6 (Equipment and Appliances) to clarify that shutoff valves serve “as a means of isolating mechanical equipment and appliances” and offers a new exception for individual geothermal ground loops.

This exception avoids the use of ambiguous language and is furthermore supported by the proposed definition for “geothermal ground-loop.” This definition appropriately describes a geothermal ground-loop as a continuous single closed-loop that serves as a conduit for fluid to create a heat convection circuit.
SECTION #: 707.6 - 707.7.2

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

707.0 Installation Practices.

707.6 Ground Heat-Exchanger Installation Practices. A ground-heat exchanger system shall be installed as follows in accordance with the following:

1. Outside piping or tubing located within 5 feet (1524 mm) of any wall or structure shall be continuously insulated with insulation that has a minimum R-5 value. Such pipe or tubing installed under the slab or basement floors shall be insulated within 5 feet (1524 mm) from the structure to the exterior point of exit from the slab.
2. Freeze protection shall be provided where the design of the ground heat exchanger system would permit the heat-transfer medium to freeze.
3. Horizontal piping shall be installed not less than 12 inches (305 mm) below the frost line.
4. Submerged heat exchangers shall be protected from damage and shall be securely fastened to the bottom of the lake or pond, or other approved submerged structure.
5. A minimum separation distance shall be maintained between the potable water intake and the submerged heat-exchanger system in accordance with the Authority Having Jurisdiction.
6. Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

707.7 Setbacks. In absence of minimum setbacks specified by the Authority Having Jurisdiction, minimum setbacks for vertical ground-heat exchanger systems shall be maintained in accordance with Section 707.7.1, and minimum setbacks for horizontal ground-heat exchanger systems shall be maintained in accordance with Section 707.7.2.

707.7.1 Vertical Systems. (6) Vertical ground-heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:

(a1) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b2) Fifty feet (15 240 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c3) Five feet (1524 mm) horizontally from buried utilities such as electrical, gas, or water.
(d4) Fifty feet (15 240 mm) from a water well.
(e5) Fifty feet (15 240 mm) from a septic tank and 50 feet (15 240 mm) from a subsurface sewage leaching field.
(f6) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.
(7) Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

707.7.2 Horizontal Systems. (6) Horizontal ground heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:

(a1) Five feet (1524 mm) horizontally from a pressure-tested sewer lateral into a building.
(b2) Ten feet (3048 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c3) Five feet (1524 mm) horizontally from buried utilities such as electrical gas or water.
(d4) Ten Feet (3048 mm) from a water well.
(e5) Ten feet (3048 mm) from a septic tank and 10 feet (3048 mm) from a subsurface leaching field.
SUBSTANTIATION:
Section 707.6 (Installation Practices) is being reorganized into multiple sections and subsections for needed clarity. Provisions pertaining to minimum setbacks are now covered under Section 707.7 (Setbacks) which addresses vertical ground heat exchangers in Section 707.7.1 (Vertical Systems) and horizontal ground heat exchangers in Section 707.7.2 (Horizontal Systems).

Item (5) was determined by the Geothermal Energy Systems Task Group to serve no purpose as it simply directs users of the code to the Authority Having Jurisdiction. Additionally, fluids used in submerged heat exchangers are required to be non-toxic and therefore offer no hazard to the potable water intake. Item (7) has been removed as it does not pertain to minimum setback requirements.

SECTION #: 707.17.8

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.

707.0 Installation Practices.

707.17 Trenches, Excavation, and Backfill. (remaining text unchanged)

707.17.8 Tracer and Warning 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 a width of not less than 3 inches (76 mm) and with burial depths in accordance with the manufacturer’s specifications, or non-metallic warning tape used in conjunction with tracer wire that complies with UL 2989. Tracer and warning markings 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. Tracer wire shall be permitted to be installed at buried pipe grade.

SUBSTANTIATION:
Section 707.17.8 (Tracer and Warning Markings) is being updated to remove the current thickness requirement for metallic detectable tape, add new language requiring burial depths in accordance with the manufacturer's specifications, and remove the existing language pertaining to placement distances from horizontal piping of the heat exchanger.

The current minimum thickness of 11/64 inch is significantly larger than the standard thickness of metallic detectable buried pipe warning tape which is 0.005 inch, and the minimum width of 6 inches is overly restrictive and prevents the use of appropriate and available metallic detectable tape.

Furthermore, the location requirement in relation to horizontal piping varies based on the selected tape and needs to be specified by the manufacturer.
SECTION #: 712.1, Table 901.1

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

712.0 General.
712.1 Applicability. Part III of this chapter shall apply to geothermal open-loop energy systems such as, but not limited to, building systems coupled with a groundwater (well) or surface water open-loop system 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. Outdoor piping, fittings, and accessories shall be in accordance with Section 703.2.

Components which come into contact with the system fluids and are installed in a geothermal open-loop system shall be constructed of corrosion resistant materials or in accordance with the Authority Having Jurisdiction. Materials which come into contact with potable water shall comply with NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372.

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Note: NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372 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 712.1 (Applicability) is being updated to better align with intent of Part III (Open-Loop Systems). In particular, minor revisions to phrasing have been made to specify that the sections pertain to “geothermal open-loop systems.” Additionally, reference to Section 703.2 (Piping and Tubing Material Standards) has been removed as such provisions currently exist under “General” requirements which apply to all other portions or parts of Chapter 7. Therefore, such reference is redundant and unnecessary.

The last paragraph of the section has also been revised to remove language which implies that some open-loop systems may be constructed without corrosion resistant materials, and two industry standards have been included to address materials which come into contact with potable water. Both NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372 offer needed protection for potable water sources, such as groundwater wells, that may be used in open-loop systems. As depicted below, these standards address potential contaminants and impurities that negatively impact water quality.

NSF/ANSI/CAN 61 establishes minimum health effects and requirements for the chemical contaminants and impurities that are indirectly imparted to drinking water from products, components, and materials used in drinking water systems. NSF/ANSI/CAN 372 establishes procedures for determination of lead content based on wetted surface areas of products.
SECTION #: 716.0 - 716.2, Figure 716.1

RECOMMENDATION:

Request to **replace** the code change proposal by this public comment.

**Part V – Ambient Temperature Loops (ATL) Geothermal.**

**716.0 Ambient Temperature Loop (ATL) Distributed Energy Systems.**

**716.1 General.** An ambient temperature loop (ATL) distributed energy system shall be installed in accordance with Section 716.2 through Section 716.6.3, and Section 717.0. ATL systems shall comply with Part I through Part IV of this chapter, as applicable. (See Figure 716.1 for a schematic of a geothermal system utilizing an ambient temperature loop.)

**716.1.1 Fourth Generation (4G) System Configuration.** A fourth-generation system configuration shall be a district geothermal energy system distributing hot water, cold water, or both to the conditioned space or building for a specific use. Where a geothermal energy source is used, such systems shall comply with Part I through Part IV of this chapter and Chapter 4.

**716.1.2 Fifth Generation (5G) System Configurations.** An advanced ambient temperature loop (ATL) system or fifth generation (5G) ATL system shall also be capable of interacting with the electric utility system as well as other utility systems and systems components.

System components shall include, but not be limited to, the following:

1. Thermally diverse buildings with independent hydronic systems.
2. Circulation loop.
3. Global control system.
4. Segment isolation capability.

**Note:** System components may include, but are not limited to, the following:

1. Electric grid-interactive enabled buildings
2. Hybrid components
3. Other renewable systems

**716.2 Permitting.** Permits required for the installation and application of an ATL distributed energy system shall be obtained as required by the Authority Having Jurisdiction.
SUBSTANTIATION:
Part V (Ambient Temperature Loops (ATL) Geothermal) is being proposed in response to the attention drawn to ambient temperature loop systems. Many states have implemented carbon reduction plans and non-combustion alternatives, and district ambient temperature loops coincide with these initiatives. Such systems lack installation requirements throughout the code and should therefore be provided.

Ambient temperature loops are high efficiency systems that recover wasted energy that is normally rejected to the atmosphere. The proposed provisions in Section 716.1.1 and Section 716.1.2 address the general requirements for fourth and fifth generation systems.
Figure 716.1 is being added as it supports the new revisions to Chapter 7 pertaining to ambient loops. Included within the schematic is an ambient temperature loop connected to solar thermal collectors, a closed-loop heat exchanger, a surface water heat exchanger, multiple heat pumps, and a closed-circuit cooling tower. Since wastewater sludge is high in organic content and offers the potential for energy recovery via thermochemical conversion technologies, a wastewater energy recovery system has been added to the schematic.

The provided schematic offers a simplified and clear visual of an ambient temperature loop system and further supports the revised applicability as shown in the previous item submitted by this Task Group. For these reasons, the figure is beneficial to the code and should be included in Chapter 7.

SECTION #: 210.0

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

210.0     - H -

Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

- Hydronic System, Ambient Temperature Loop (ATL). A closed loop piping system with central pumping that includes various heat sources and heat sinks to hold the loop fluid temperature near the long term average ambient air temperature for a given geographical location. The sources/sinks can be passive (e.g., a ground loop, a body of water, sewer effluent) or active (e.g., a cooling tower) and further can include opportunistic, or unique locally available waste or by-product heat sources (e.g., data center, industrial process). The closed loop piping system typically controls or engages these sources/sinks to maintain the loop temperature to meet the seasonal requirements as well as specific building needs.

- Hydronic System, Fifth Generation (5G) System Configurations. An advanced ambient temperature (ATL) system that distributes near ambient temperature water among and between end use buildings that are equipped with water-source heat pumps or other water source HVAC equipment. Such systems stand in contrast to fourth generation (4G) systems that distribute hot water or chilled water to buildings to serve facility loads.

- Hydronic System, Fourth Generation (4G) System Configurations. A district geothermal energy system that distributes dedicated hot water and chilled water for direct use in the conditioned space.

SUBSTANTIATION:

The definitions for "fourth generation (4G) system configuration" and "fifth generation (5G) system configuration" are included as such systems are not currently defined and are not commonly known. A definition for "ambient temperature loop (ATL)" was also added to support the proposed code changes pertaining to these systems. The provided language appropriately defines ATL systems and informs users of the code that ATLs are closed-loop piping systems which include various heat sources and heat sinks.

As requested in the other recommendations generated by the Geothermal Energy Systems Task Group, these definitions are being located under the main definition for "hydronic system."
SECTION #: 716.3 - 716.5

RECOMMENDATION:

Request to accept the code change proposal as submitted by this public comment.

716.3 Ambient Loop Temperature Range. The operating loop temperature range of an ambient temperature loop (ATL) system shall be not less than the freezing point of the circulating fluid and not more than the maximum temperature, as required by the manufacturer’s installation instructions for the attached heat pump equipment in accordance with Section 716.3.1 and Section 716.3.2. The ATL system shall use treated water as the heat transfer medium.

716.3.1 ATL Operating Temperature. For equipment listed to AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2, the controlled temperature range of the ambient closed-loop shall be not less than 7°F (4°C) above the freezing point of the transport fluid and 10°F (6°C) below the (collective) heat pump lowest maximum inlet supply temperature as recommended by the manufacturer’s instructions.

Exception: Equipment that is not listed to AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2, the controlled temperature range of the ambient closed loop shall be in accordance with Section 716.3.2 for minimum and maximum temperatures.

716.3.2 ATL Operating Temperature Range for Mixed Equipment Certifications. The source inlet temperature range of any attached equipment shall govern the design operating temperature range. Such equipment shall be identified in the design documentation. In any case, the most restrictive minimum and maximum inlet supply temperatures, as recommended by the manufacturer’s instructions, shall determine the system operating temperature range.

716.4 Shutoff Valve. An automatic shutoff valve shall be provided for each individual building or facility transferring energy to or from an ATL distribution system. The automatic shutoff valve shall automatically shutoff upon operating command.

716.4.1 Shutoff Valve Operation. The operation of the automatic shutoff valve shall be in accordance with the system operating procedures. Where the operation of a shutoff valve was due to an emergency response, an auxiliary heating or cooling methodology shall be provided in accordance with Section 717.1.2.

716.5 Bypass. The ATL distributed energy system shall be provided with bypass path(s) to reroute the circulating fluid when necessary.

Note: AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2 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:

Section 716.3 through Section 716.5 further address the characteristics and required components of an ATL system. In particular, Section 716.3.1 is necessary as it provides the required controlled temperature range for ambient temperature loops where heat pumps are listed to AHRI/ASHRAE/ISO 13256-1 or AHRI/ASHRAE/ISO 13256-2.

For systems incorporating heat pumps not listed to those standards, Section 716.3.2 addresses the controlled temperature range in a conservative manner by requiring the most restrictive minimum and maximum supply temperatures recommended by the manufacturer.

Section 716.4 is important as it requires automatic shutoff valves for each building or facility connected to the ATL system. The proposed language in Section 716.4.1 ensures automatic emergency response via these shutoff valves and also requires available back-up heating or cooling methods.
SECTION #: 716.6 - 716.6.3

RECOMMENDATION:

Request to accept the code change proposal as submitted by this public comment.

716.6 Metering. Where meters are required by the system design, meter(s) shall be located as specified by the manufacturer on each consumptive or supply source, and the range of the metering shall be appropriate to the thermal properties and flow rate(s) of the transport fluid.

716.6.1 Sub-Metering System Specification. The entire energy measurement system shall be provided with a sub-metering system. The metering system shall be calibrated and shall consist of a flow meter, temperature sensors, temperature thermowells, or other required mechanical installation metering. The sub-meter traceable calibration shall comply with a National Institute of Standards Technology (NIST) traceable calibration program or in accordance with the Authority Having Jurisdiction and shall be provided with an ATL distributed energy system.

716.6.2 BTU/Thermal Meters. Where used, the Btu/thermal meter shall be bidirectional and shall provide the following information via digital or analog display:
(1) LCD, and via serial network communications.
(2) Total energy, Btu (kWh).
(3) Energy rate, Btu/h (kW).
(4) Total flow, gal (L).
(5) Flow rate, gpm (L/s).
(6) Supply temperature, °F (°C).
(7) Return temperature, °F (°C).
Each Btu/thermal meter shall be factory programmed for its specific application and shall be re-programmable to adjust for specific site conditions.

716.6.3 Flow Meter. Where used, the flow meter shall be provided with the following information via digital or analog display:
(1) LCD, and via serial network communications.
(2) Instantaneous fluid rate, gpm (L/s).
(3) Cumulative fluid flow volume, gal (L).

SUBSTANTIATION:
Section 716.6 through Section 716.6.3 are intended to require energy movement data with sufficient accuracy to both measure system performance and individual asset performance. The respective metering methods also provide the basis for a use or energy transfer custody platform. In addition, this section is recognizing that there are multiple ways to effectively measure energy transfer.

Section 716.6.1 calls out the National Institute of Standards Technology (NIST) traceable calibration program for sub-meters to provide users of the code with the most appropriate method of calibration. To prevent overly restrictive requirements, the proposed language also leaves the calibration program selection up to the Authority Having Jurisdiction. Such calibration is necessary since the entire energy measurement system is provided with the sub-metering system which relies on inputs from flow meters, temperature sensors, thermowells, etc.

Section 716.6.2 then addresses thermal metering which allows for the measurement of energy used to heat and cool individual units. It is the most accurate method for monitoring heating and cooling consumption. For these reasons, the proposed requirements for metering are necessary and further support the remaining items submitted pertaining to ATLs in Chapter 7.
SECTION #: 218.0, 221.0, 222.0, 717.0 - 717.1.2

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

717.0 ATL Distributed Energy Systems Design Requirements.
717.1 Thermal Resources. The ambient temperature loop (ATL) shall be permitted to connect to a thermal resource(s). Such resources may be an alternative energy source and sink, such as but not limited to, solar photovoltaic (PV), solar thermal, combined heat power (CHP), and phase change thermal storage. These systems shall be installed and comply with the respective system requirements. ATL distributed energy systems coupled with solar thermal systems shall comply with this code or equivalent. ATL systems coupled with a solar photovoltaic (PV) or a photovoltaic thermal system (PVT) shall comply with this code or NFPA 70, or equivalent. These systems shall optimize the use of the equipment and energy based on the system design intent.

717.1.1 System Performance. The System Coefficient of Performance (SCOP) shall account for the net COP of each individual component(s) in the district. The SCOP shall be provided by the designer and included in the system design documents.

717.1.2 Emergency Response. An auxiliary heating or cooling methodology shall be provided with the ATL controls and shall be adequate to provide temporary service in the absence of an ATL energy transfer. Emergency source/sink measures such as, but not limited to, control subroutines that move energy between spaces in the building, the use of locally connected ground-source assets, combined heat and power (CHP), conventional equipment, and other renewable systems shall be permitted to be used.

218.0 - P -
Photovoltaic Thermal System (PVT). A hybrid system which incorporates a heating or cooling solar thermal system in combination with a solar photovoltaic system to generate both electrical and thermal energy. These systems are designed to improve system efficiency and simultaneously produce or reject thermal energy.

221.0 - S -
System Coefficient of Performance (SCOP). A ratio of the total system energy moved to the total system purchased energy.

222.0 - T -
Thermal Resources. A source for heating and a sink for cooling. There are two types of sources:
(1) Conventional-type: such systems are known as geothermal energy systems, including air-source resources and ground-source resources.
(2) Opportunistic-type: such systems use water-source resources (e.g., oceans, rivers, raw sewage pipes, treated sewage outfall, potable water pipes, etc.), process byproduct heat resources (e.g., data center cooling process reject heat, industrial process reject heat, etc.), and other resources.

Note: NFPA 70 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:
By definition, the ATL will use multiple types of sources and sinks along with multiple heat transfer devices. This section is intended to demonstrate different assets that are commonly used in conjunction with the ATL to meet specific system needs and ensure that temporary service reductions are anticipated in the design process.
A standard metric, system coefficient of performance (SCOP) must be used to evaluate the ATL design intent performance to include transport energy and wasted energy recovered. Sources and sinks are usually spread across the ATL system, GeoMicroDistrict, or thermal highway and provisions should be made to handle temporary reduction or loss of services utilizing assets currently connected to the ATL.

Section 717.1 (Thermal Resources) is not intended to include a redundant system but rather to address the use of existing or attached thermal resources. Resulting from additional review by the Geothermal Energy Systems Task Group, both solar photovoltaic (PV) and photovoltaic thermal systems (PVT) have been included as potential renewable energy sources that ATLs may be coupled with. Such systems are used in the industry to improve thermal and electrical efficiency and should also be listed with this section. For added clarity, a definition for “photovoltaic thermal system (PVT)” has been proposed for insertion into Chapter 2 (Definitions).

Furthermore, definitions for "thermal resource" and "system coefficient of performance (SCOP)" are being added as they are not currently defined in the code and such inclusion will assist the end user with interpreting and applying the listed provisions.

SECTION #: 206.0, 209.0, 222.0, 717.2 - 717.2.3

RECOMMENDATION:

Request to accept the code change proposal as submitted by this public comment.

717.2 District Load Profiles. The district load profile of an ambient temperature loop (ATL) distributed energy system shall be identified and shall be included in the basis-of-design (BOD).

717.2.1 System Asset Identification. System assets shall be listed and included in the system design. The system assets shall include, but not be limited to, the following:

1. Building type and quantity.
2. Natural or constructed sources and sinks such as ground water, boreholes, etc.
3. Other renewable assets.
5. Potable and non-potable water or fluid sources.
6. Conventional assets such as boilers and cooling towers.
7. Other geothermal micro-districts or thermal highways.

717.2.2 Driver Building. The driver building profile shall be identified in an ATL distributed energy system and shall be reported in the design documents.

717.2.3 Diversity Factor. The diversity factor and/or anticipated wasted energy recovery component of the geothermal micro-district shall be identified by the designer, and this information shall be included in the drawings and specifications.

206.0 - D -
Driver Building. One or more building(s) or facility(s) that determine the upper and lower temperature limits of a hot fluid or cold fluid delivery system.

209.0 - G -
Geothermal Micro-District. A collection of buildings and facilities on an independently pumped ambient temperature loop (ATL) that supplies or receives energy. An independent segment served by a thermal highway. Also known as GeoMicroDistrict.
222.0 - T -
Thermal Highway. A collection of one or more geothermal micro-districts that acts as an energy transport system and supplies or accepts energy from multiple geothermal micro-districts, individual buildings, or other sources. Also known as convective circulation circuit.

SUBSTANTIATION:
Along with System Coefficient of Performance (SCOP), there are several additional unique characteristics and components that must be identified in the ATL design documents. These components must be identified accurately to communicate design intent. In addition, identification of system assets, the driver building(s), and diversity factors (e.g. wasted energy recovery) are imperative for building management system code development, validation/ commissioning processes, long term operations management, and future system expansion.

Furthermore, the definitions for "driver building," "geothermal micro-district," and "thermal highway" are being added to support the proposed language. Such terminology will assist with the enforcement of the section and provide clarity for the end user.
Hydronics Systems Task Group Report
Hydronics Systems Task Group Report

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Jeff Matson (Chair)
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TM Sales
Western Allied Mechanical
Watts Water Technologies
Plastics Pipe Institute
Self - Persons
Sound Geothermal Corporation
LH Stevens Constructors LLC
UPONOR LTD

During the Uniform Solar, Hydronics & Geothermal Code Technical Committee (USHGC TC) Meeting on June 21, 2022, the USHGC TC requested that the Hydronics Systems Task Group reconvene to review their respective proposals, revise current definitions pertaining to these systems, and address Uniform Mechanical Code correlation items to generate public comments for Technical Committee consideration.

The scope of the Hydronics Systems Task Group, as approved by the USHGC TC, was to review and update current provisions for hydronic piping systems to improve requirements for design, construction, location, and installation.

The Task Group reviewed their proposals published in the 2022 USHGC Report on Proposals affecting Chapter 2 (Definitions) and Chapter 4 (Hydronics) and generated recommendations in the form of public comments for Technical Committee consideration. Following the USHGC TC Meeting on June 21, 2022, four meetings were conducted to complete this review and discussion.

During the first meeting and second meeting, the Task Group generated recommendations pertaining to the applicability of Chapter 4, freeze protection, expansion tank sizing, oxygen diffusion corrosion, joints and connections, automatic makeup fluid, and insulation for snow and ice melt systems. The third meeting then focused on generating recommendations which prohibited comingling of hydronic system fluids with potable water. Such work resulted in major revisions to Section 402.0 (Protection of Potable Water Supply), including new language pertaining to dual purpose water heaters.

The final meeting focused on terminology pertaining to hydronic systems which were categorized into either general terms or those which described system types. This included revisions to terminology for general terms such as “balancing valve,” “closed-loop hydronic system,” and “expansion tank” as well as new terminology for “atmospheric closed-loop hydronic system” and “non-oxygen barrier closed-loop hydronic system.” All terminology for hydronic system types were also relocated under the main definition for “hydronic system.”

Upon completion of the final Task Group meeting, 14 public comments were generated and submitted to the USHGC TC for consideration during the May 16, 2023 USHGC Technical Committee Meeting.
SECTION #: 204.0

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

204.0 – B – Balancing Valves. A valve that regulates the flow rate of *a fluid* liquid, to achieve uniform distribution, throughout multiple collectors.

SUBSTANTIATION:
The definition of “balancing valve” is being revised for clarity and technical correctness. Balancing valves are flow regulators and are not used specifically for uniform distribution through collectors. The modified terminology removes improper specificity and clarifies that such valves allow you to design the system as intended rather than only for uniform distribution.

SECTION #: 210.0

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

210.0 – H – Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

*Hydronic System, Closed-Loop System.* A hydronic system where the fluid is enclosed in a piping system that is not vented to the atmosphere in which a captive fluid is circulated to transfer thermal energy between heat exchange sources and emitters installed on the system loop.

SUBSTANTIATION:
The definition of “closed-loop system” is being revised to “closed-loop hydronic system” in order to more appropriately align with the scope of the USHGC. The existing terminology references “piping system[s] that [are] not vented,” and this is not a true characteristic of a closed-loop. The appropriate description is “captive fluid” as shown in the proposed modification. Additionally, language has been included which clarifies that this captive fluid is circulated to transfer thermal energy between the heat sources and emitters. Such revisions are also inline with the other definitions proposed by this Task Group pertaining to “atmospheric closed-loop hydronic system” and “non-oxygen barrier closed-loop hydronic system.” (See Item #40 Public Comment 2.) The combination of these three definitions provides a better overall understanding of the variations within closed-loop hydronic systems.

SECTION #: 207.0

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

207.0 – E – Expansion Tank. A vessel installed in a system to accommodate the thermal expansion and contraction of the system fluid provide a pneumatic cushion for the expansion of fluid.
**SUBSTANTIATION:**
The definition of “expansion tank” is being updated to remove overly specific language pertaining to “pneumatic cushion,” which is not a defining characteristic but rather one subset of expansion tanks. The new language is more general and encompasses the overall purpose of these tanks which is to accommodate thermal expansion and contraction of system fluid.

**SECTION #: 401.1**

**RECOMMENDATION:**
Request to accept the code change proposal as modified by this public comment.

**401.0 General.**
**401.1 Applicability.** This chapter shall apply to hydronic piping systems that are part of heating, cooling, ventilation, refrigeration, and air conditioning systems. Such piping systems include steam, hot water, radiant heating and cooling, chilled water, steam condensate, condenser water, solar thermal systems, ground source heat pump systems, snow and ice melt systems, ambient temperature loops (ATL), and district thermal energy loops. The regulations of this chapter shall govern the construction, location, and installation of hydronic piping systems.

**SUBSTANTIATION:**
Section 401.1 (Applicability) is being revised to remove reference to “ambient temperature loops.” Since ambient temperature loops are a subset or type of district thermal energy loops, this reference is redundant and unnecessary.

**SECTION #: 401.11, Table 401.11**

**RECOMMENDATION:**
Request to accept the code change proposal as modified by this public comment.

**401.0 General.**
**401.11 Freeze Protection.** Hydronic systems and components shall be designed, installed, and protected from freezing. Where glycol is used for freeze protection, the percent of glycol by volume shall be determined based on the freezing point of the solution and type of mixture in accordance with Table 401.11, or the manufacturer’s specifications.

(below is shown for information purposes only)

<table>
<thead>
<tr>
<th>PERCENT GLYCOL BY VOLUME (% v/v)</th>
<th>FREEZING POINT, °F</th>
<th>ETHYLENE GLYCOL</th>
<th>PROPYLENE GLYCOL</th>
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<tbody>
<tr>
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<td>50</td>
<td>-35</td>
<td>-28</td>
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</tr>
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</table>

*Ethylene glycol shall not be used in one- and two-unit residential systems. In existing systems where ethylene glycol is used, there shall be no direct or permanent potable water connections. Where a temporary potable water connection is required, a backflow preventer shall be installed.*
The minor revision to Section 401.11 (Freeze Protection) is being proposed as it prevents overly restrictive language pertaining to glycol used in hydronic systems for freeze protection. Since there are hydronic systems which use non-chemical methods of freeze protection, there must be language which states that these provisions only apply where glycol is utilized. In summary, the additional language is necessary as it clarifies that "where glycol is used" as a means of freeze protection, the percent glycol by volume must comply with Table 401.11 (Percent Glycol Mixtures).

SUBSTANTIATION:

SECTION #: 401.11.1

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

401.0 General.

401.11 Freeze Protection. (remaining text unchanged)

401.11.1 Antifreeze Requirements. Antifreeze shall be added to a closed hydronic system where one or more of the following conditions are met exist:

1. System component(s) are exposed to freezing conditions during normal operation,
2. The hydronic system serves as a snow and ice melt system in accordance with Section 417.0, or
3. Where required by the equipment manufacturer.

Exception: Antifreeze shall not be required where a system is continuously monitored or specifically designed not to require antifreeze, and is not subject to freezing as a result of either of the following:

1. Loss of electrical power.
2. Loss of a fuel source.

SUBSTANTIATION:

Section 401.11.1 (Antifreeze Requirements) is being updated to include minor revisions as well as new exceptions for these requirements. The phrase “during normal operation” is vague and excludes systems which are dormant but still may contain hydronic system fluids within the piping system. In such circumstances, there exists the possibility of pipe bursts or leaks resulting from freezing conditions. In order to protect these systems under varying circumstances, this phrasing should be removed.

The exceptions have been added to prevent overly restrictive provisions pertaining to antifreeze requirements as there are systems which may be “continuously monitored or specifically designed not to require antifreeze.” These exceptions correlate with IAPMO/ANSI H1001.1 (Standard for Quality of Heat Transfer Fluids Used in Hydronics Systems), which was previously accepted for reference in Section 401.6 (Heat Transfer Fluid Quality). For both consistency between requirements and the inclusion of allowable exceptions, the revisions are necessary.
SECTION #: 402.1, 402.3 - 402.5, 403.4

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

402.0 Protection of Potable Water Supply.
402.1 Prohibited Sources Connections. Hydronic systems or parts thereof, shall be constructed in such a manner that polluted, contaminated water, or substances shall not enter hydronic system fluid does not enter a portion of the potable water distribution system or from being separately delivered to any potable water fixture or point of use 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.

402.3 Protection of Potable Water. Where a hydronic system makeup fluid supply is connected to a potable water system, the potable water system shall be protected from backflow from the hydronic system in accordance with the Uniform Plumbing Code.

402.4 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.

402.5 Dual Purpose Water Heaters. Dual purpose water heaters shall be configured to maintain fluid separation between the potable water and the hydronic system fluid. Where an integral heat exchanger is installed in a dual purpose water heater, the installation shall comply with the requirements for a single wall heat exchanger in Section 313.1. Scald protection shall be provided on the potable water circuit in compliance with ASSE 1070/ASME A112.1070/CSA B125.70, point of generation requirements.

403.0 Capacity of Heat Source.

403.4 Potable Water as a Hydronic Fluid. Potable water shall not be used as a hydronic fluid in an open-loop heating system unless all of the following conditions are met:
(1) A maximum of one system loop using potable water as the hydronic fluid is allowed per heat source;
(2) The total length of piping of the heating system containing potable water does not exceed 50 feet (15,240 mm);
(3) The total volume of potable water in the heating system loop, including the volume within the heat-distribution unit(s), heat exchanger, or radiant surface, does not exceed 13 gallons (49 L); and
(4) The normal operating supply temperature of the potable water to the heat-distribution unit(s), heat exchanger, or radiant surface is not less than 140°F (60°C).

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>ASSE 1070/ASME A112.1070/CSA B125.70-2020</td>
<td>Water Temperature Limiting Devices</td>
<td>Valves</td>
<td>402.5</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ASSE 1070/ASME A112.1070/CSA B125.70 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.
313.0 Heat Exchangers.
313.1 General. Systems utilizing heat exchangers shall protect the potable water system from being contaminated by
the heat transfer medium. Systems that incorporate a single-wall heat exchanger to separate potable water from the
heat-transfer fluid shall meet the following requirements:
(1) Heat transfer medium is either potable water or contains fluids recognized as safe by the Food and Drug
Administration (FDA) as food grade.
(2) A tag or label shall be securely affixed to the heat source with the word “CAUTION” and the following statements:
(a) The heat transfer medium shall be water or other nontoxic fluid recognized as safe by the FDA.
(b) The maximum operating pressure of the heat exchanger shall not exceed the maximum operating pressure of the
potable water supply.
(3) The word “CAUTION” and the statements listed above shall have an uppercase height of not less than 0.120 of an
inch (3.05 mm). The vertical spacing between lines of type shall be not less than 0.046 of an inch (1.168 mm).
Lowercase letters shall be not less than compatible with the uppercase letter size specification. Systems that do not
comply with the requirements for a single-wall heat exchanger shall install a double-wall heat exchanger. Double-wall
heat exchangers shall separate the potable water from the heat transfer medium by providing a space between the two
walls that are vented to the atmosphere.

SUBSTANTIATION:
During their discussion and review, the Task Group determined that comingling of hydronic fluid and potable
water is too great of a health risk to be allowed by any codes, whose primary purpose is that of public health and
safety. Furthermore, once a system has a final inspection, the code and the Authority Having Jurisdiction no
longer have any control over how it is used or maintained.

When operation is contingent on the function of disparate components, as opposed to being affected entirely by a
listed appliance, there is simply no possibility of legislating the health and safety issues over the lifetime of the
installation. Because this practice is not specifically prohibited by other codes, it is necessary to address this
directly in the USHGC.

Section 402.1 (Prohibited Connections) is best stated as a prohibition against connections, i.e., comingling. This
is to bolster the prohibition against comingling, by specifically addressing what happens after passing the
mandatory backflow preventer.

Resulting from this determination, the Task Group also revised Section 402.3 (Protection of Potable Water) and
Section 402.4 (Compatibility) and proposed new Section 402.5 (Dual Purpose Water Heaters). Requirements for
protection of the potable water supply are still bound by the plumbing code, however additional language has
been provided to specify that the potable water system is to be protected from backflow from the hydronic system.
This language is clearer and more appropriately aligns with the provisions of the chapter.

Section 402.5 (Dual Purpose Water Heaters) includes the removed language from Section 402.4 (Compatibility)
pertaining to single wall heat exchangers in compliance with Section 313.1 (Heat Exchangers – General), and the
use of the phrase “integral heat exchanger” covers dual circuit tankless water heaters permitted under these
provisions. Additionally, provisions have been included requiring dual purpose water heaters to maintain fluid
separation between the potable water and hydronic system fluid. In efforts to offer additional safety, scald
protection requirements have also been proposed. ASSE 1070/ASME A112.1070/CSA B125.70 specifically
addresses performance requirements for water temperature limiting devices intended to limit the hot or tempered
water temperature supplied to fixtures to reduce the risk of scalding.
Since the Task Group intends to prohibit comingling of system fluids, Section 403.4 (Potable Water as a Hydronic Fluid) is being deleted in its entirety.

The Task Group’s public comment submitted on Item #048 further supports this prohibition of comingled system fluids and proposes the necessary revisions to Section 412.4 (Automatic Makeup Fluid).

SECTION #: 408.4

RECOMMENDATION:

Request to replace the code change proposal by this public comment.

408.0 Expansion Tanks.

408.4 Sizing. Expansion tanks shall be sized to accept the design expansion volume of the fluid in the system. The minimum capacity of a closed-type expansion tank shall be sized in accordance with Section 605.3.

(below is shown for information purposes only)

605.3 Minimum Capacity of Closed-Type Tanks. The minimum capacity for a gravity-type hot water system expansion tank shall be in accordance with Table 605.3(1). The minimum capacity for a forced-type hot water system expansion tank shall be in accordance with Table 605.3(2) or Equation 605.3(1). The minimum capacity for diaphragm tanks shall be in accordance with Table 605.3(2) or Equation 605.3(2).

\[ V_{t(\text{forced type})} = \frac{(C_1 t - C_2)V_s}{P_a - P_f} \]  
\[ V_{t(\text{diaphragm})} = \frac{(C_1 t - C_2)V_s}{1 - \frac{P_f}{P_o}} \]  

Where:

- \( C_1 = 0.00041 \)
- \( C_2 = 0.0466 \)
- \( V_t = \) Minimum volume of expansion tank, gallons (L)
- \( V_s = \) Volume of system, not including expansion tank, gallons (L)
- \( t = \) Average operating temperature, °F (°C).
- \( P_a = \) Atmospheric pressure, pounds per square inch (kPa)
- \( P_f = \) Fill pressure, pounds per square inch (kPa)
- \( P_o = \) Maximum operating pressure, pounds per square inch (kPa)

For SI units: \( C_1 = 0.000738, C_2 = 0.03348, 1\text{ gallon} = 3.785\text{ L}, \) °C = (°F-32)/1.8, 1 pound per square inch = 6.8947 kPa

SUBSTANTIATION:

The minor revision to Section 408.4 (Sizing) is necessary as it provides needed clarity. As shown above, Section 605.3 (Minimum Capacity of Closed-Type Tanks) provides equations for determination of tank volumes. Since the language already states “the minimum capacity of closed-type expansion tanks” are to be in accordance with Section 605.3, the use of the term “sized” is repetitive and unnecessary.
SECTION #: 409.4 - 409.4.2

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

409.0 Materials.

409.4 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.

409.4.1 Vented Atmospheric Closed-Loop Systems. All components installed in a vented closed-loop system shall be constructed of non-ferrous or other corrosion resistant materials.

409.4.2 Non-Oxygen Barrier Closed-Loop Systems. All components installed in a non-oxygen barrier system shall be constructed of non-ferrous or other corrosion resistant materials.

SUBSTANTIATION:
The exception to Section 409.4 (Oxygen Diffusion Corrosion) is being replaced by subsections which specifically address the types of closed-loop systems where the use of “non-ferrous or other corrosion resistant materials” is required. Vented atmospheric closed-loop systems have been included within these subsections to specifically address systems in which the storage component is open to the atmosphere and must be covered under the provisions of “closed-loop systems.” Where closed-loop systems experience continual oxygenation, corrosion resistance measures are imperative for thermal efficiency and ultimately system longevity.

In efforts to ensure clarity and proper applicability of requirements, both “vented atmospheric closed-loop system” and “non-oxygen barrier closed-loop system” have been appropriately defined in another recommendation provided by this Task Group. Additionally, these requirements correlate with the latest edition of the UMC.

SECTION #: 210.0

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

210.0 - H –

Hydronic System. Relating to, or being a system of heating or cooling that involves the transfer of heat by circulating a fluid in a liquid state (such as water) or a gaseous state (such as steam).

**Hydronic System, Atmospheric Closed-Loop.** A hydronic system wherein the system fluid may be exposed to the atmosphere.

**Hydronic System, Non-Oxygen Barrier Closed-Loop.** A hydronic system constructed all or in part with pipe or tubing that is not intended to restrict the diffusion of oxygen into the system fluid.

SUBSTANTIATION:
In support of the other recommendations proposed by this Task Group for Item #040, terminology has been provided for “atmospheric closed-loop hydronic system” and “non-oxygen barrier closed-loop hydronic system.” Both of these definitions are essential to understanding the provisions laid out in Section 409.4.1 (Vented Atmospheric Closed-Loop Systems) and Section 409.4.2 (Non-Oxygen Barrier Closed-Loop Systems) as proposed. The inclusion of such terminology is imperative for interpretation of provisions as well as regulation of the variations of closed-loop systems covered by the USHGC.
SECTION #: 410.11

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

410.0 Joints and Connections.

410.11 Polyethylene of Raised Temperature (PE-RT). Joints between polyethylene of raised temperature (PE-RT) tubing and fittings shall comply be installed in accordance with the manufacturer’s installation instructions and shall comply with the standards listed in Table 409.1. Metal insert fittings, metal compression fittings, and plastic fittings shall be manufactured to and marked in accordance with the standards for fittings in Table 409.1.

SUBSTANTIATION:
The proposed modifications to Section 410.11 [Polyethylene of Raised Temperature (PE-RT)] are being made to clarify that joints between PE-RT tubing and fittings must be “installed” in accordance with manufacturer’s installation instructions. Since PE-RT piping and fittings must “comply” with standards listed in Table 409.1, additional phrasing has been included which states this.

SECTION #: 410.16 - 410.16.2.1, Table 901.1

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

410.0 Joints and Connections.

410.16 Joints Between Different Materials. Joints between various different types of materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 410.16.1 and Section 410.16.2.

410.16.1 Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints. Joints from copper or copper alloy pipe or tubing to threaded pipe of a material other than copper or copper alloy shall be made by the use of copper alloy adapter, copper alloy nipple [minimum 6 inches (152 mm)], dielectric fitting, or dielectric union in accordance with ASSE 1079. The joint between the copper or copper alloy pipe or tubing and the fitting shall be a soldered, brazed, flared, or pressed joint and the connection between the threaded pipe and the fitting shall be made with a standard pipe size threaded joint.

410.16.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of plastic or other types of piping materials, approved adapter or transition fittings designed and listed for the specific transition intended shall be used. Except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material.

410.16.2.1 Transition Joint. For non-pressurized systems rated at 25 psi (172 kPa) or less, a solvent cement transition joint between ABS and PVC drainpipe and fittings shall be made using listed transition solvent cement in accordance with ASTM D3138. PVC and ABS pipe and fittings shall not be solvent welded to any other unlike material.
TABLE 901.1
REFERENCED STANDARDS

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<td>ASTM D3138-2021</td>
<td>Standard Specification for Solvent Cements for Transition Joints Between Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Non-Pressure Piping Components</td>
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(portion of table not shown remains unchanged)

Note: ASTM D3138 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:
Section 410.16.1 (Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints) is being revised to include the phrase “of a material other than copper or copper alloy” as the original sentence is unclear and does not specify that the connection is from copper alloy pipe or tubing to threaded pipe of a different material. This revision does not alter the intent of the code section but rather adds clarity to support it.

Section 410.16.2 (Plastic Pipe to Other Materials) revisions include both removal of the last sentence as well as the phrase “and listed.” As required by Section 302.1 (Minimum Standards), “pipe, pipe fittings, appliances, appurtenances, equipment, material, and devices used shall be listed (third party certified) by a listing agency (accredited conformity assessment body) as complying with the approved applicable recognized standards referenced in this code and shall be free from defects.” Therefore, the inclusion of the phrase “and listed” is unnecessary and repetitive.

Regarding the removal of the last sentence to Section 410.16.2, please see the respective requirements provided within the plumbing code:

CHAPTER 3 (GENERAL REQUIREMENTS)
310.0 Prohibited Fittings and Practices.
310.10 ABS and PVC Transition Joints. Except as provided in Section 705.9.4, PVC and ABS pipe and fittings shall not be solvent welded to any other unlike dissimilar material.

CHAPTER 6 (WATER SUPPLY AND DISTRIBUTION)
605.16 Joints Between Various Materials.
605.16.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of piping, approved types of adapter or transition fittings designed for the specific transition intended shall be used.

CHAPTER 7 (SANITARY DRAINAGE)
705.9 Special Joints.
705.9.4 Transition Joint. A solvent cement transition joint between ABS and PVC building drain and building sewer shall be made using listed transition solvent cement in accordance with ASTM D3138.

It should be noted that Chapter 7 of the UPC is specific to sanitary drainage systems and such provisions are not applicable for use in hydronic systems. For these reasons, the language which states, “except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material” should be removed from USHGC Section 410.16.2 (Plastic Pipe to Other Materials). In order to generate requirements focusing on non-pressurized lines for condensate drainage on low stakes piping, new Section 410.16.2.1 (Transition Joint) is being proposed. This section addresses solvent cement joints between ABS and PVC and aligns with the referenced standard, ASTM D3138, which is only applicable to non-pressurized systems (rated at 25 psi or less).
SECTION #: 412.4 - 412.4.2

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.

412.0 Pressure and Flow Controls.

412.4 Automatic Makeup Fluid. Automatic makeup fluid shall be in accordance with Section 412.4.1 for potable water makeup fluid or Section 412.4.2 for nonpotable makeup fluid.

412.4.1 Potable 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 potable water makeup supply shall be located at the expansion tank connection or other approved location. Where the hydraulic fluid contains a chemical additive, a potable water supply shall be protected in accordance with Section 402.0. On systems using only water as a heat transfer medium, and where pressurization is achieved using a potable water supply, a pressure-reducing valve shall be installed on a potable water makeup 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.

412.4.2 Nonpotable Makeup Fluid. Makeup fluid systems that are designed to add pre-mixed antifreeze solutions shall be permitted. Such systems shall include, but not be limited to, glycol feeders and limited-volume reservoir systems.

SUBSTANTIATION:
Section 412.4 (Automatic Makeup Fluid) has been divided to address hydronic systems which use “potable water” or “pre-mixed antifreeze solutions” as automatic makeup fluid.

Section 412.4.1 (Potable Makeup Fluid) includes the necessary revisions to ensure that provisions are explicit to systems in which only potable water is used for makeup fluid. Within this subsection, reference to Section 402.0 (Protection of Potable Water Supply) has been removed and new language specific to potable water makeup feed lines has been provided. During their discussion and review, the Task Group determined that comingling of hydronic fluid and potable water is too great of a health risk to be allowed by any codes, whose primary purpose is that of public health and safety. Furthermore, once a system has a final inspection, the code and the Authority Having Jurisdiction no longer have any control over how it is used or maintained. When operation is contingent on the function of disparate components, as opposed to being effected entirely by a listed appliance, there is simply no possibility of legislating the health and safety issues over the lifetime of the installation.

Section 412.4.2 (Nonpotable Makeup Fluid) then addresses makeup fluid systems using premixed antifreeze solutions. In further support of prohibiting comingling of system fluids, this subsection requires the use of either a “system pressurization unit or glycol feeder.” Such devices maintain required fluid pressures and chemical mixtures in closed-loop hydronic systems to compensate for fluid loss during air elimination processes. The use of chemical feeders also addresses issues associated with system fluid dilution which negatively affects the lifespan of hydronic systems.

The Task Group’s public comment submitted on Item #030 further supports this prohibition of comingled system fluids and proposes the necessary revisions to Section 402.0 (Protection of Potable Water Supply).
SECTION #: 417.2.6

RECOMMENDATION:

Request to accept the code change proposal as modified by this public comment.

417.0 Snow and Ice Melt Systems.

417.2 Snow and Ice Melt Controls. (remaining text unchanged)

417.2.6 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 subgrade and be extended as close as practicable to the outside edges of the concrete.

Exception: An approved engineered alternative method of construction in accordance with Section 302.2.

(below is shown for information purposes only)

302.2 Alternate Materials and Methods of Construction Equivalency. Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire-resistance, effectiveness, durability, and safety over those prescribed by this code. Technical documentation shall be submitted to the Authority Having Jurisdiction to demonstrate equivalency. The Authority Having Jurisdiction shall have the authority to approve or disapprove the system, method, or device for the intended purpose. However, the exercise of this discretionary approval by the Authority Having Jurisdiction shall have no effect beyond the jurisdictional boundaries of said Authority Having Jurisdiction. An alternate material or method of construction so approved shall not be considered as in accordance with the requirements, intent, or both of this code for a purpose other than that granted by the Authority Having Jurisdiction where the submitted data does not prove equivalency.

SUBSTANTIATION:

Section 417.2.6 (Insulation) is being revised to include an exception for approved engineered alternative methods of construction in compliance with Section 302.2 (Alternate Materials and Methods of Construction Equivalency). Providing an insulation requirement is acceptable, however R-values vary based on geographical location. Design should be based on local conditions, and therefore such requirements should align with the building code or energy code as adopted by the Authority Having Jurisdiction. For this reason, the exception is necessary.
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CHAPTER 1
ADMINISTRATION

101.0 General.
101.1 Title. This document shall be known as the “Uniform Solar, Hydronics and Geothermal Code,” may be cited as such, and will be referred to herein as “this code.”
101.2 Scope. The provisions of this code shall apply to the erection, installation, alteration, addition, repair, relocation, replacement, addition to, use or maintenance of solar energy, water heating, appliances intended for space heating or cooling, swimming pool heating, process heating, geothermal and hydronic systems, snow and ice melt systems and use of any solar energy systems or swimming pool, spa or hot tub systems within this jurisdiction.
101.3 Purpose. This code is an ordinance providing minimum requirements and standards for the protection of the public health, safety, and welfare.
101.4 Unconstitutional. Where a section, subsection, sentence, clause, or phrase of this code is, for a reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this code. The legislative body hereby declares that it would have passed this code, and each section, subsection, sentence, clause, or phrase thereof, irrespective of the fact that one or more sections, subsections, sentences, clauses, and phrases are declared unconstitutional.
101.5 Validity. Where a provision of this code, or the application thereof to a person or circumstance, is held invalid, the remainder of the code, or the application of such provision to other persons or circumstances, shall not be affected thereby.

102.0 Applicability.
102.1 Conflicts Between Codes. Where the requirements within the jurisdiction of this code conflict with the requirements of the plumbing or mechanical code, this code shall prevail. In instances where this code, applicable standards, or the manufacturer’s installation instructions conflict, the more stringent provisions shall prevail. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall prevail.

102.2 Existing Installation. Systems lawfully in existence at the time of the adoption of this code shall be permitted to have their use, maintenance, or repair continued where the use, maintenance, or repair is in accordance with the original design and location and no hazard to life, health, or property has been created by such system.

102.3 Maintenance. Systems, materials, and appurtenances, both existing and new, of a premise under the Authority Having Jurisdiction shall be maintained in operating condition. Devices or safeguards required by this code shall be maintained in accordance with the code edition under which installed.

The owner or the owner’s designated agent shall be responsible for maintenance of the system. To determine compliance with this subsection, the Authority Having Jurisdiction shall be permitted to cause a system to be reinspected.

102.4 Additions, Alterations, Renovations, or Repairs. Additions, alterations, renovations or repairs shall conform to that required for a new system without requiring the existing system to be in accordance with the requirements of this code. Additions, alterations, renovations or repairs shall not cause an existing system to become unsafe, insanitary, or overloaded.

Additions, alterations, renovations or repairs to existing system installations shall comply with the provisions for new construction unless such deviations are found to be necessary and are first approved by the Authority Having Jurisdiction.

102.5 Health and Safety. Where compliance with the provisions of this code fails to eliminate or alleviate a nuisance, or other dangerous or insanitary condition that involves health or safety hazards, the owner or the owner’s agent shall install such additional facilities or shall make such repairs or alterations as ordered by the Authority Having Jurisdiction.

102.6 Changes in Building Occupancy. Systems that are a part of a building or structure undergoing a change in use or occupancy, as defined in the building code, shall be in accordance with the requirements of this code that are applicable to the new use or occupancy.

102.7 Moved Structures. Parts of the system of a building or part thereof that is moved from one foundation to another, or from one location to another, shall be in accordance with the provisions of this code for new installations and completely tested as prescribed elsewhere in this section for new work, except that walls or floors need not be removed during such test where equivalent means of inspection acceptable to the Authority Having Jurisdiction are provided.

102.8 Appendices. The provisions in the appendices are intended to supplement the requirements of this code and shall not be considered part of this code unless formally adopted as such.

103.0 Duties and Powers of the Authority Having Jurisdiction.
103.1 General. The Authority Having Jurisdiction shall be the Authority duly appointed to enforce this code. For such purposes, the Authority Having Jurisdiction shall have the powers of a law enforcement officer. The Authority Having Jurisdiction shall have the power to render interpretations of this code and to adopt and enforce rules and regulations supplemental to this code as deemed necessary in order to clarify the application of the provisions of this code. Such interpretations, rules, and regulations shall comply with the intent and purpose of this code.

In accordance with the prescribed procedures and with the approval of the appointing authority, the Authority Having Jurisdiction shall be permitted to appoint a such number of technical officers, inspectors, and other employees as shall be authorized from time to time. The Authority Having Jurisdiction shall be permitted to deputize such inspectors or
employees as necessary to carry out the functions of the code enforcement agency.

The Authority Having Jurisdiction shall be permitted to request the assistance and cooperation of other officials of this jurisdiction so far as required for the discharge of the duties required by this code or other pertinent law or ordinance.

103.2 Liability. The Authority Having Jurisdiction charged with the enforcement of this code, acting in good faith and without malice in the discharge of the Authority Having Jurisdiction’s duties, shall not thereby be rendered personally liable for damage that accrues to persons or property as a result of an act or by reason of an act or omission in the discharge of such duties. A suit brought against the Authority Having Jurisdiction or employee because of such act or omission performed in the enforcement of provisions of this code shall be defended by legal counsel provided by this jurisdiction until final termination of such proceedings.

103.3 Applications and Permits. The Authority Having Jurisdiction shall be permitted to require the submission of plans, specifications, drawings, and such other information in accordance with the Authority Having Jurisdiction, prior to the commencement of, and at a time during the progress of, work regulated by this code.

The issuance of a permit upon construction documents shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said construction documents or from preventing construction operations being carried on thereunder where in violation of this code or of other pertinent ordinance or from revoking a certificate of approval where issued in error.

103.3.1 Licensing. Provision for licensing shall be determined by the Authority Having Jurisdiction.

104.0 Permits.

104.1 Permits Required. It shall be unlawful for a person, firm, or corporation to make an installation, alteration, repair, replacement, or remodel a system regulated by this code except as permitted in Section 104.2, or to cause the same to be done without first obtaining a separate permit for each separate building or structure.

104.2 Exempt Work. A permit shall not be required for the following:

1. The repairing of leaks in pipes, valves, or components, provided such repairs do not involve or require the replacement or rearrangement of valves, pipes, or components.

2. Replacement of a component part that does not alter its original approval and is in accordance with other applicable requirements of this code.

Exemption from the permit requirements of this code shall be deemed not to grant authorization for work to be done in violation of the provisions of the code or other laws or ordinances of this jurisdiction.

104.3 Application for Permit. To obtain a permit, the applicant shall first file an application therefore in writing on a form furnished by the Authority Having Jurisdiction for that purpose. Such application shall:

1. Identify and describe the work to be covered by the permit for which application is made.

2. Describe the land upon which the proposed work is to be done by legal description, street address, or similar description that will readily identify and definitely locate the proposed building or work.

3. Indicate the use or occupancy for which the proposed work is intended.

4. Be accompanied by construction documents and other data in accordance with Section 104.3.1.

5. Be signed by the permittee or the permittee’s authorized agent. The Authority Having Jurisdiction shall be permitted to require evidence to indicate such authority.

6. Give such other data and information in accordance with the Authority Having Jurisdiction.

104.3.1 Construction Documents. Construction documents, engineering calculations, diagrams, and other data shall be submitted in two or more sets, or in a digital format where permitted by the Authority Having Jurisdiction, with each application for a permit. The construction documents, computations, and specifications shall be prepared by, and the system designed by, a registered design professional. Construction documents shall be drawn to scale with clarity to identify that the intended work to be performed is in accordance with the code.

Exception: The Authority Having Jurisdiction shall be permitted to waive the submission of construction documents, calculations, or other data where the Authority Having Jurisdiction finds that the nature of the work applied for is such that reviewing of construction documents is not necessary to obtain compliance with the code.

104.3.2 Plan Review Fees. Where a plan or other data is required to be submitted in accordance with Section
104.3.1. a plan review fee shall be paid at the time of submitting construction documents for review.

The plan review fees for system work shall be determined and adopted by this jurisdiction.

The plan review fees specified in this subsection are separate fees from the permit fees specified in Section 104.5.

Where plans are incomplete or changed so as to require additional review, a fee shall be charged at the rate shown in Table 104.5.

**104.3.3 Time Limitation of Application.** Applications for which no permit is issued within 180 days following the date of application shall expire by limitation, plans and other data submitted for review thereafter, shall be returned to the applicant or destroyed by the Authority Having Jurisdiction. The Authority Having Jurisdiction shall be permitted to extend the time for action by the applicant for a period not to exceed 180 days upon request by the applicant showing that circumstances beyond the control of the applicant have prevented action from being taken. No application shall be extended more than once. In order to renew action on an application after expiration, the applicant shall resubmit plans and pay a new plan review fee.

**104.4 Permit Issuance.** The application, construction documents, and other data filed by an applicant for a permit shall be reviewed by the Authority Having Jurisdiction. Such plans shall be permitted to be reviewed by other departments of this jurisdiction to verify compliance with applicable laws under their jurisdiction. Where the Authority Having Jurisdiction finds that the work described in an application for permit and the plans, specifications, and other data filed therewith are in accordance with the requirements of the code and other pertinent laws and ordinances, and that the fees specified in Section 104.5 have been paid, the Authority Having Jurisdiction shall issue a permit therefore to the applicant.

**104.4.1 Approved Plans or Construction Documents.** Where the Authority Having Jurisdiction issues the permit where plans are required, the Authority Having Jurisdiction shall endorse in writing or stamp the construction documents “APPROVED.” Such approved construction documents shall not be changed, modified, or altered without authorization from the Authority Having Jurisdiction, and the work shall be completed in accordance with approved plans.

The Authority Having Jurisdiction shall be permitted to issue a permit for the construction of a part of a system before the entire construction documents for the whole system have been submitted or approved, provided adequate information and detailed statements have been filed in accordance with the pertinent requirements of this code. The holder of such permit shall be permitted to proceed at the holder’s risk without assurance that the permit for the entire building, structure, or system will be granted.

**104.4.2 Validity of Permit.** The issuance of a permit or approval of construction documents shall not be construed to be a permit for, or an approval of, a violation of the provisions of this code or other ordinance of the jurisdiction. No permit presuming to give authority to violate or cancel the provisions of this code shall be valid.

The issuance of a permit based upon plans, specifications, or other data shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said plans, specifications, and other data or from preventing building operations being carried on thereunder where in violation of this code or of other ordinances of this jurisdiction.

**104.4.3 Expiration.** A permit issued by the Authority Having Jurisdiction under the provisions of this code shall expire by limitation and become null and void where the work authorized by such permit is not commenced within 180 days from the date of such permit, or where the work authorized by such permit is suspended or abandoned at a time after the work is commenced for a period of 180 days. Before such work is recommenced, a new permit shall first be obtained to do so, and the fee therefore shall be one-half the amount required for a new permit for such work, provided no changes have been made or will be made in the original construction documents for such work, and provided further that such suspension or abandonment has not exceeded 1 year.

**104.4.4 Extensions.** A permittee holding an unexpired permit shall be permitted to apply for an extension of the time within which work shall be permitted to commence under that permit where the permittee is unable to commence work within the time required by this section. The Authority Having Jurisdiction shall be permitted to extend the time for action by the permittee for a period not exceeding 180 days upon written request by the permittee showing that circumstances beyond the control of the permittee have prevented the action from being taken. No permit shall be extended more than once. In order to renew action on a permit after expiration, the permittee shall pay a new full permit fee.

**104.4.5 Suspension and Revocation.** The Authority Having Jurisdiction shall be permitted, with written notification, to suspend or revoke a permit issued under the provisions of this code where the permit is issued in error or on the basis of incorrect information supplied or in violation of other ordinance or regulation of the jurisdiction.

**104.4.6 Retention of Plans.** One set of approved construction documents and computations shall be retained by the Authority Having Jurisdiction until final approval of the work covered therein.

One set of approved construction documents, computations, and manufacturer’s installation instructions shall be returned to the applicant, and said set shall be kept on the site of the building or work at times during which the work authorized thereby is in progress.

**104.5 Fees.** Fees shall be assessed in accordance with the provisions of this section and as set forth in the fee schedule, Table 104.5. The fees are to be determined and adopted by this jurisdiction.

**104.5.1 Work Commencing Before Permit Issuance.** Where work for which a permit is required by this code has been commenced without first obtaining
said permit, a special investigation shall be made before a permit is issued for such work.

104.5.2 Investigation Fees. An investigation fee, in addition to the permit fee, shall be collected whether or not a permit is then or subsequently issued. The investigation fee shall be equal to the amount of the permit fee that is required by this code if a permit were to be issued. The payment of such investigation fee shall not exempt a person from compliance with other provisions of this code, nor from a penalty prescribed by law.

104.5.3 Fee Refunds. The Authority Having Jurisdiction shall be permitted to authorize the refunding of a fee as follows:

(1) The amount paid hereunder that was erroneously paid or collected.

(2) Refunding of not more than a percentage, as determined by this jurisdiction where no work has been done under a permit issued in accordance with this code.

The Authority Having Jurisdiction shall not authorize the refunding of a fee paid except upon written application filed by the original permittee not to exceed 180 days after the date of fee payment.

105.0 Inspections and Testing.

105.1 General. Systems for which a permit is required by this code shall be inspected by the Authority Having Jurisdiction.

No system or portion thereof shall be covered, concealed, or put into use until inspected and approved as prescribed in this code. Neither the Authority Having Jurisdiction nor the jurisdiction shall be liable for expense entailed in the removal or replacement of material required to permit inspection. Systems regulated by this code shall not be connected to the water, energy fuel supply, or the sewer system until authorized by the Authority Having Jurisdiction.

105.2 Required Inspection. New system work and such portions of existing systems as affected by new work, or changes, shall be inspected by the Authority Having Jurisdiction to ensure compliance with the requirements of this code and to ensure that the installation and construction of the system is in accordance with approved plans. The Authority Having Jurisdiction shall make the following inspections and other such inspections as necessary. The permittee or the permittee’s authorized agent shall be responsible for the scheduling of such inspections as follows:

(1) Underground inspection shall be made after trenches or ditches are excavated and bedded, piping installed, and before backfill is put in place.

(2) Rough-in inspection shall be made prior to the installation of wall or ceiling membranes.

(3) Final inspection shall be made upon completion of the installation.

105.2.1 Uncovering. Where a system, or part thereof, which is installed, altered, or repaired, is covered or concealed before being inspected, tested, and approved as prescribed in this code, it shall be uncovered for inspection after notice to uncover the work has been issued to the responsible person by the Authority Having Jurisdiction.

The requirements of this section shall not be considered to prohibit the operation of system equipment installed to replace existing equipment serving an occupied portion of the building in the event a request for inspection of such equipment has been filed with the Authority Having Jurisdiction not more than 72 hours after such replacement work is completed, and before a portion of such system is concealed by a permanent portion of the building.

105.2.2 Other Inspections. In addition to the inspections required by this code, the Authority Having Jurisdiction shall be permitted to require other inspections to ascertain compliance with the provisions of this code and other laws that are enforced by the Authority Having Jurisdiction.

105.2.3 Inspection Requests. It shall be the duty of the person doing the work authorized by a permit to notify the Authority Having Jurisdiction that such work is ready for inspection. The Authority Having Jurisdiction shall be permitted to require that a request for inspection be filed not less than 1 working day before such inspection is desired. Such request shall be permitted to be made in writing or by telephone, at the option of the Authority Having Jurisdiction.

It shall be the duty of the person requesting inspections in accordance with this code to provide access to and means for proper inspection of such work.

105.2.4 Advance Notice. It shall be the duty of the person doing the work authorized by the permit to notify the Authority Having Jurisdiction, orally or in writing that said work is ready for inspection. Such notification shall be given not less than 24 hours before the work is to be inspected.

105.2.5 Responsibility. It shall be the duty of the holder of a permit to make sure that the work will stand the test prescribed before giving the notification.

The equipment, material, and labor necessary for inspection or tests shall be furnished by the person to whom the permit is issued or by whom inspection is requested.

105.2.6 Reinspections. A reinspection fee shall be permitted to be assessed for each inspection or reinspection where such portion of work for which inspection is called is not complete or where required corrections have not been made.

This provision shall not be interpreted as requiring reinspection fees the first time a job is rejected for failure to be in accordance with the requirements of this code, but as controlling the practice of calling for inspections before the job is ready for inspection or reinspection.

Reinspection fees shall be permitted to be assessed where the approved plans are not readily available to the inspector, for failure to provide access on the date for which the inspection is requested, or for deviating from plans requiring the approval of the Authority Having Jurisdiction.

To obtain reinspection, the applicant shall file an application therefore in writing upon a form furnished
for that purpose and pay the reinspection fee in accordance with Table 104.5.

In instances where reinspection fees have been assessed, no additional inspection of the work will be performed until the required fees have been paid.

105.3 Testing of Systems. Systems shall be tested and approved in accordance with this code or the Authority Having Jurisdiction. Tests shall be conducted in the presence of the Authority Having Jurisdiction or the Authority Having Jurisdiction’s duly appointed representative. No test or inspection shall be required where a system, or part thereof, is set up for exhibition purposes and has no connection with water or an energy fuel supply. In cases where it would be impractical to provide the required water or air tests, or for minor installations and repairs, the Authority Having Jurisdiction shall be permitted to make such inspection as deemed advisable in order to be assured that the work has been performed in accordance with the intent of this code. Joints and connections in a system shall be airtight, gastight, or watertight for the pressures required by the test.

105.3.1 Defective Systems. In buildings or premises condemned by the Authority Having Jurisdiction because of an insanitary condition of the system, or part thereof, the alterations in such system shall be in accordance with the requirements of this code.

105.3.2 Retesting. Where the Authority Having Jurisdiction finds that the work will not pass the test, necessary corrections shall be made, and the work shall be resubmitted for test or inspection.

105.3.3 Approval. Where prescribed tests and inspections indicate that the work is in accordance with this code, a certificate of approval shall be issued by the Authority Having Jurisdiction to the permittee on demand.

105.4 Connection to Service Utilities. No person shall make connections from a source of energy or fuel to a system or equipment regulated by this code and for which a permit is required until approved by the Authority Having Jurisdiction. No person shall make connection from a water-supply line nor shall connect to a sewer system regulated by this code and for which a permit is required until approved by the Authority Having Jurisdiction. The Authority Having Jurisdiction shall be permitted to authorize temporary connection of the system equipment to the source of energy or fuel for the purpose of testing the equipment.

106.0 Violations and Penalties.

106.1 General. It shall be unlawful for a person, firm, or corporation to erect, construct, enlarge, alter, repair, move, improve, remove, convert, demolish, equip, use, or maintain a system or permit the same to be done in violation of this code.

106.2 Notices of Correction or Violation. Notices of correction or violation shall be written by the Authority Having Jurisdiction and shall be permitted to be posted at the site of the work, mailed, or delivered to the permittee or their authorized representative.

Refusal, failure, or neglect to comply with such notice or order within 10 days of receipt thereof, shall be considered a violation of this code and shall be subject to the penalties set forth by the governing laws of the jurisdiction.

106.3 Penalties. A person, firm, or corporation violating a provision of this code shall be deemed guilty of a misdemeanor, and upon conviction thereof, shall be punishable by a fine, imprisonment, or both set forth by the governing laws of the jurisdiction. Each separate day or portion thereof, during which a violation of this code occurs or continues, shall be deemed to constitute a separate offense.

106.4 Stop Orders. Where work is being done contrary to the provisions of this code, the Authority Having Jurisdiction shall be permitted to order the work stopped by notice in writing served on persons engaged in the doing or causing such work to be done, and such persons shall forthwith stop work until authorized by the Authority Having Jurisdiction to proceed with the work.

106.5 Authority to Disconnect Utilities in Emergencies. The Authority Having Jurisdiction shall have the authority to disconnect a system to a building, structure, or equipment regulated by this code in case of an emergency where necessary to eliminate an immediate hazard to life or property.

106.6 Authority to Condemn. Where the Authority Having Jurisdiction ascertains that a system or portion thereof, regulated by this code, has become hazardous to life, health, or property, or has become insanitary, the Authority Having Jurisdiction shall order in writing that such system either be removed or placed in a safe or sanitary condition. The order shall fix a reasonable time limit for compliance. No person shall use or maintain a defective system after receiving such notice.

Where such system is to be disconnected, written notice shall be given. In cases of immediate danger to life or property, such disconnection shall be permitted to be made immediately without such notice.

107.0 Board of Appeals.

107.1 General. In order to hear and decide appeals of orders, decisions, or determinations made by the Authority Having Jurisdiction relative to the application and interpretations of this code, there shall be and is hereby created a Board of Appeals consisting of members who are qualified by experience and training to pass upon matters pertaining to a system design, construction, and maintenance and the public health aspects of such systems and who are not employees of the jurisdiction. The Authority Having Jurisdiction shall be an ex-officio member and shall act as secretary to said board but shall have no vote upon a matter before the board. The Board of Appeals shall be appointed by the governing body and shall hold office at its pleasure. The board shall adopt rules of procedure for conducting its business and shall render decisions and findings in writing to the appellant with a duplicate copy to the Authority Having Jurisdiction.

107.2 Limitations of Authority. The Board of Appeals shall have no authority relative to interpretation of the administrative provisions of this code, nor shall the board be empowered to waive requirements of this code.
TABLE 104.5
SYSTEM PERMIT FEES\(^2\)

**Permit Issuance**

1. For issuing each permit ........................................................................................................................................ 1
2. For issuing each supplemental permit .................................................................................................................. 1

**Unit Fee Schedule** (in addition to Items 1 and Item 2 above)

1. For Collectors (including related piping and regulating devices):
   - Up to 1000 square feet .................................................................................................................................... 1
   - Between 1001 square feet and 2000 square feet ............................................................................................. 1
   - More than 2000 square feet, $5.00 plus $1.00 per 1000 square feet or fraction thereof over 2000 square feet .................................................................................................................. 1

2. For Storage Tanks (including related piping and regulating devices):
   - Up to 750 gallons ............................................................................................................................................ 1
   - Between 751 gallons and 2000 gallons ........................................................................................................... 1
   - Exceeding 2000 gallons, $3.00 plus $1.00 per 1000 or fraction thereof exceeding 2000 gallons ........................................................................................................................................ 1

3. For Rock Storage:
   - Up to 1500 cubic feet ...................................................................................................................................... 1
   - Between 1501 cubic feet and 3000 cubic feet ................................................................................................. 1
   - More than 3000 cubic feet, $3.00 plus $1.00 per 1000 cubic feet or fraction thereof over 3000 cubic feet .................................................................................................................. 1

4. For each appliance or piece of equipment regulated by this code for which no fee is listed .................................. 1

**Other Inspections and Fees**

1. Inspections outside of normal business hours ......................................................................................................... 1
2. Reinspection fee ....................................................................................................................................................... 1
3. Inspections for which no fee is specifically indicated ............................................................................................. 1
4. Additional plan review required by changes, additions, or revisions to approved plans (minimum charge - \(\frac{1}{2}\) hour) .................................................................................................................. 1
5. Plan Check Fee:
   - Where specific plans are required, a plan check fee shall be charged equal to one-half the total permit fee, excluding the permit issuance fee .................................................................................................................. 1

For SI units: 1 square foot = 0.0929 m\(^2\), 1 gallon = 3.785 L, 1 cubic foot = 0.0283 m\(^3\)

**Notes:**

1 Jurisdiction will indicate its fees here.

2 These fees do not include permit fees for parts of the system that are subject to the requirements of other applicable codes.
CHAPTER 2
DEFINITIONS

201.0 General.
201.1 Applicability. For the purpose of this code, the following terms have the meaning indicated in this chapter.

No attempt is made to define ordinary words, which are used in accordance with their established dictionary meanings, except where a word has been used loosely, and it is necessary to define its meaning as used in this code to avoid misunderstanding.

202.0 Definition of Terms.
202.1 General. The definitions of terms are arranged alphabetically according to the first word of the term.

202.2 Terms Defined in Other Documents. Where terms are not defined in this chapter and defined in the building code, mechanical code, plumbing code, electrical code, and fire code; such terms shall have meanings as defined in those codes.

203.0 — A —
Absorber. That part of the solar collector that receives the incident radiation energy.
Absorptance. The collecting of heat, measured as a percent of total radiation available.
Accepted Engineering Practice. That which conforms to technical or scientific-based principles, tests, or standards that are accepted by the engineering profession.
Accessible. Where applied to a device, appliance, or equipment, “accessible” means having access thereto, but which first may require the removal of an access panel, door, or similar obstruction.
Accessible, Readily. Having a direct access without the necessity of removing panel, door, or similar obstruction.
Air Break, Drainage. The drain from an appliance or appurtenance that discharges indirectly into another receptacle at a point below the flood level rim and above the trap seal.
Air Gap, Drainage. The unobstructed vertical distance through the free atmosphere between the lowest openings from a pipe, appliance, or appurtenance conveying waste to the flood-level rim of the receptor.
Air Mass. The ratio of the mass of atmosphere, in the actual earth-sun path, to the mass that would exist if the sun were directly overhead at sea level.
Alternating-Current (AC) Module (Alternating-Current Photovoltaic Module). A complete environmentally protected unit consisting of solar cells, inverter, and other components, designed to produce ac power. [NFPA 70:690.2100]
Ambient Temperature. Surrounding temperature.
Anchors. See Supports.
204.0 – B –
Backflow. The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from sources other than its intended source.
Balancing Valves. A valve that regulates the flow rate of a fluid liquid, to achieve uniform distribution, throughout multiple collectors.
Boiler. A closed vessel used for heating water or liquid, or for generating steam or vapor by direct application of heat from combustible fuels or electricity.
Borehole. A penetration into the earth at any angle, typically drilled, bored, cored, driven, hydraulically advanced, or otherwise constructed for geothermal system installations.
Branch Circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [NFPA 70:100]
Building. A structure built, erected, and framed of component structural parts designed for the housing, shelter, enclosure, or support of persons, animals, or property of any kind.
Building Code. The building code that is adopted by the jurisdiction.

205.0 – C –
Calcium Hardness. A measure of dissolved calcium compounds and mineral content of water. It is measured as calcium carbonate (CaCO₃).
Certified Designer. An individual who has successfully completed the formal training, testing, project design experience, and continuing education credits to be granted the IGSHPA/AEE title of Certified GeoExchange Designer, or other equivalent approved certification program.
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]
Chilled Water. Water or fluid that is cooled below the surrounding air temperature via mechanical or other means for the purpose of removing excess heat from conditioned spaces or equipment via hydronic piping distribution.
Circuit Breaker. A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating. [NFPA 70:100]
Circulating Air. Air being conveyed from or to a collector through openings, ducts, plenums, or concealed spaces to a heat exchanger or storage media.
Circulators (Circulating Pump). A device that circulates liquids within a closed circuit for an intended purpose.
Coastal High Hazard Areas. An area within the flood hazard area that is subject to high-velocity wave action, and shown on a Flood Insurance Rate Map or other flood hazard map as Zone V, VO, VE or V1-30.
Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.
Collector. See Solar Collector.
Collector, Concentrating. A solar collector that uses reflectors, lenses, or other optical elements to concentrate the radiant energy passing through the aperture onto an absorber of which the surface area is smaller than the aperture area.
Collector System. That section of the solar system that includes the collector and piping or ducts from the collector to the storage system.
Collector Tilt. The angle above horizontal at which a solar heat collector is positioned.
Combination Temperature and Pressure-Relief Valve. A relief valve that actuates when a set temperature, pressure, or both is reached. Also known as a T&P valve.
Combustible Liquid. A liquid having a flash point at or above 100°F (38°C). Combustible liquids shall be divided into the following classifications:
1. Class II liquids having a flash point above 100°F (38°C) and below 140°F (60°C).
2. Class IIIA liquids having a flash point at or above 140°F (60°C) and below 200°F (93°C).
3. Class IIIB liquids having a flash point at or above 200°F (93°C).
   The classifications of combustible liquids do not include compressed gases or cryogenic fluids.
Concentration Ratio. The ratio of the aperture area to the absorber area (in concentrating solar collectors).
Concentrator. Reflector of lens designed to focus solar energy into a reduced area.
Condensate. The liquid phase produced by condensation of a particular gas or vapor.
Conditioned Space. An area, room, or space normally occupied and being heated or cooled for human habitation by any equipment.
Construction Documents. Plans, specifications, written, graphic, and pictorial documents prepared or assembled for describing the design, location, and physical characteristics of the elements of a project necessary for obtaining a permit.
Contamination. An impairment of the quality of the potable water that creates an actual hazard to the public health through poisoning or through the spread of disease by sewage, industrial fluids, or waste. Also defined as High Hazard.
Cooling. Air cooling to provide a room or space temperature of 68°F (20°C) or above.
Cooling System. All of the equipment, including associated refrigeration, intended or installed for the purpose of cooling air by mechanical means and discharging such air into any room or space. This definition shall not include an evaporative cooler.
Copper Alloy. A homogenous mixture of two or more metals in which copper is the primary component, such as brass and bronze.
Corrosion. The gradual degradation and destruction of metals and other natural and synthetic materials typically result-
ing from chemical and/or electrochemical reactions with their environment including, but not limited to, weathering, dissolution, and direct photochemical attack.

**Cover, Collector (Glazing).** The material covering the aperture to provide thermal and environmental protection.

**Crawl Space.** In a building, an area accessible by crawling, having a clearance less than human height, for access to plumbing or wiring, storage, etc.

**Critical Level.** The critical level (C-L or C/L) marking on a backflow prevention device or vacuum breaker is a point conforming to approved standards and established by the testing laboratory (usually stamped on the device by the manufacturer) that determines the minimum elevation above the flood-level rim of the fixture or receptor served at which the device may be installed. Where a backflow prevention device does not bear a critical level marking, the bottom of the vacuum breaker, combination valve, or the bottom of such approved device shall constitute the critical level.

**Cross-Connection.** A connection or arrangement, physical or otherwise, between a potable water supply system and a tank, receptor, equipment, or device through which it may be possible for nonpotable, used, unclean, polluted and contaminated water, or other substances to enter into a part of such potable water system under any condition.

### 206.0 – D –

**DC-to-DC Converter.** A device that can provide an output dc voltage and current at a higher or lower value than the input dc voltage and current. [NFPA 70:100]

**DC-to-DC Converter Circuit.** The dc circuit conductors connected to the output of a dc-to-dc converter. [NFPA 70:100]

**DC-to-DC Converter Output Circuit.** The dc circuit conductors connected to the output of a dc-to-combiner for the dc-to-de converter source circuits. [NFPA 70:690.2]

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

**Department Having Jurisdiction.** The Authority Having Jurisdiction, including other law enforcement agencies affected by a provision of this code, whether such agency is specifically named or not.

**Design Flood Elevation.** The elevation of the “design flood,” including wave height, relative to the datum specified on the community’s legally designated flood hazard map. In areas designated as Zone AO, the design flood elevation shall be the elevation of the highest existing grade of the building’s perimeter plus the depth number in feet (m) specified on the flood hazard map. In areas designated as Zone AO where a depth number is not specified on the map, the depth number shall be taken as being equal to 2 feet (610 mm).

**Design Load.** The maximum load that a component, system or structure is anticipated to undergo during design operating conditions.

**Design Pressure.** The maximum allowable pressure for which a specific part of a system is designed.

**Design Temperature.** The maximum allowable continuous or intermittent temperature for which a specific part of a solar energy system is designed to operate safely and reliably.

**Developed Length.** The length along the center line of a pipe and fittings.

**Diameter.** Unless specifically stated, “diameter” is the nominal diameter as designated commercially.

**Direct-Current (DC) Combiner.** An enclosure that includes devices used to connect two or more PV system dc circuits in parallel. [NFPA 70:692.100]

**Direct Exchange (DX).** A ground-source heat pump that circulates a refrigerant through a closed-loop system.

**Direct Expansion System.** See Direct Exchange (DX).

**Disconnecting Means.** A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [NFPA 70:100]

**Discrete Products in Plenums.** Individual distinct products which are non-continuous such as pipe hangers, duct registers, duct fittings and duct straps.

**Distribution System.** That section of the solar system from the storage system to the point of use.

**District Thermal Energy Loop.** A closed-loop piping system with central pumping that includes various heat sources and heat sinks. The sources/sinks can be passive (e.g., a ground loop, a body of water, sewer effluent) or active (e.g., boiler, cooling tower, heat pumps, or chillers) and further can include opportunistic, or unique locally available waste or by-product heat sources (e.g., data center, industrial process). The loop may run exterior to conditioned spaces in order to serve multiple structures and the heat exchange devices installed within.

**Diversion Charge Controller.** Equipment that regulates the output of a source or charging process of a battery or other energy storage device by diverting power from energy storage to direct-current or alternating-current loads, or to an interconnected utility service. [NFPA 70:692.100]

**Drain.** A pipe that carries waste or waterborne wastes in a building drainage system.

**Drainage System.** Includes the piping within a premise that conveys liquid waste to a legal point of disposal.

**Drainback System.** A closed-loop system, which allows gravity draining of the heat transfer fluid into, lower portions or the solar loop under prescribed circumstances.

**Driver Building.** One or more building(s) or facility(s) that determine the upper and lower temperature limits of a hot fluid or cold fluid delivery system.

**Dual Purpose Water Heater.** An appliance utilized as intended to be a heat source for both space heating and domestic hot water applications.

**Duct.** A tube or conduit for transmission of air, fumes, vapors, or dusts. This definition shall not include:

1. A vent, vent connector, or chimney connector.
2. A tube or conduit wherein the pressure of the air exceeds 1 psi (7 kPa).
3. The air passages of listed self-contained systems.
DEFINITIONS

207.0 – E –
Electric Supply Stations. Locations containing the generating stations and substations, including their associated generator, storage battery, transformer, and switchgear areas. [NFPA 70:691.2100]

Electrical (Auxiliary) Heating. Electrical heating element immersed into the storage.

Electrical Code. The National Electrical Code (NEC) promulgated by the National Fire Protection Association (NFPA), as adopted by this jurisdiction.

Emittance. The amount of heat radiated back from the solar collector, measured as a percent of energy absorbed by the collector.

Enclosure. A room or box used to store solar components.

Energy Collector Fluid. That fluid used to transfer energy from the collector to the storage system or point of use.

Energy Storage Fluid (or Media). That fluid (or media) used in the storage container for storing collected energy.

Energy Transfer Fluid. That fluid used within a closed system either from the collector to the storage system or from the storage system to the point of use.

Equipment. A general term including materials, fittings, devices and apparatus used as part of or in connection with installations regulated by this code.

Essentially Nontoxic Transfer Fluid. Fluid generally recognized as safe by the Food and Drug Administration (FDA) as food grade.

Existing Work. A solar system or part thereof that has been installed prior to the effective date of this code.

Expansion Tank. A vessel installed in a system to accommodate the thermal expansion and contraction of the system fluid provide a pneumatic cushion for the expansion of fluid.

External Auxiliary Heating. Auxiliary heating device located outside the storage. The heat is transferred to the storage by direct or indirect charging via a charge loop.

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]

Flammable Liquid. Any liquid that has a flash point below 100°F (38°C) and has a vapor pressure not exceeding 40 psi (276 kPa) at 100°F (38°C). Flammable liquids shall be known as Class I liquids and shall be divided into the following classifications:

1. Class IA liquids having a flash point below 73°F (23°C) and a boiling point below 100°F (38°C).
2. Class IB liquids having a flash point below 73°F (23°C) and a boiling point at or above 100°F (38°C).
3. Class IC liquids having a flash point at or above 73°F (23°C) and below 100°F (38°C).

Flash Point. The minimum temperature corrected to a pressure of 14.7 psia (101 kPa) at which a test flame causes the vapors of a portion of the sample to ignite under the conditions specified by the test procedures and apparatus. The flash point of a liquid shall be determined in accordance with ASTM D56, ASTM D93, or ASTM D3278.

Flat Plate Collector. A panel (nonconcentrating type) of a suitable material that converts solar energy into usable energy and the absorbing surface is essentially planar.

Flood Hazard Area. The greater of the following two areas:

1. The area within a floodplain subject to a 1 percent or greater chance of flooding in any given year.
2. The area designated as a flood hazard area on a community’s flood hazard map, or otherwise legally designated.

Flood-Level Rim. The top edge of a receptor from which water overflows.

Freeze Protection. Any method for protecting solar thermal systems from damage due to freezing conditions where installed in locations where freezing ambient temperature conditions exist.

Freeze Protection, Fail-Safe. A freeze protection method that does not rely on the activation or continued operation of any mechanical or electrical component.

209.0 – G –
Generating Capacity, Inverter. The sum of parallel-connected inverter maximum continuous output power at 104°F (40°C) in watts (W), or kilowatts (kW), volt-amperes (VA), or kilovolt-amperes (kVA). [NFPA 70:100]

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 70:691.2100]

Geoexchange. See Geothermal Energy System.

Geothermal Energy System. A system that exchanges thermal energy between the earth, subsurface water, and/or bodies of water, for the purposes of space heating and cooling, and/or water heating. Such energy may be derived from conduction with the earth or solar radiation impacting the ground.

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

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

Geothermal Ground-Loop. A conduit for a fluid, such as water or a water-based antifreeze solution, used to create a circuit that serves as a heat sink, source, or storage device.

Geothermal Micro-District. A collection of buildings and facilities on an independently pumped ambient temperature loop (ATL) that supplies or receives energy. An independent
DEFINITIONS

Segment served by a thermal highway. Also known as GeoMicroDistrict.

Grade. The slope or fall of a line of pipe in reference to a horizontal plane. In drainage, it is usually expressed as the fall in a fraction of an inch (mm) or percentage slope per foot (m) length of pipe.

Gravity Tank. A water storage tank in which fluid is stored at atmospheric pressure and distributed by gravity flow in a downfeed system.

Ground-Heat Exchanger. An underground closed-loop heat exchanger through which a heat-transfer medium passes to and from a heat pump or other rated mechanical equipment. It includes the buried pipe and connecting main(s) up to and terminating with the building.

Ground-Source Heat Pump. A term that is applied to a variety of systems that use the ground, groundwater, or surface water as a heat source and sink. The general terms include ground-coupled (GCHP), groundwater (GWHP), and surface-water (SWHP) heat pumps. Many parallel terms exist [e.g., geothermal heat pumps (GHP), geo-exchange, and ground-source (GS) systems] and are used to meet a variety of marketing or institutional needs.

Grounded, Functionally. A system that has an electrical ground reference for operational purposes that is not solidly grounded. [NFPA 70:212.2.100]

Groundwater. Water that exists beneath the earth’s surface.

Groundwater Source. A geothermal energy system that uses the groundwater as a heat source or sink.

210.0 – H –

Hangers. See Supports.

Hazardous Material. A substance or mixture of substances that is toxic, corrosive, flammable, an irritant, a sensitizer, and that presents a potential threat to the health of humans or animals.

Heat Exchanger. A device that transfers heat from one medium to another.

Heat Transfer Medium. The medium used to transfer energy from the solar collectors to the thermal storage or load.

Heating Degree Day. A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day when the mean temperature is less than 65°F (18°C), there exist as many degree days as there are Fahrenheit degrees difference in temperature between mean temperature for the day and 65°F (18°C).

Heating Equipment. Includes warm air furnaces, warm air heaters, combustion products vents, heating air-distribution ducts and fans, and all steam and hot water piping, together with all control devices and accessories installed as part of, or in connection with, any environmental heating system or appliance regulated by this code.

Heliostat. A reflecting surface mounted on an axis to direct the sun’s rays to a fixed point.
more heat exchangers submerged in a body of water or buried in the ground, fluidly coupled to one or more heat exchangers or heat pumps serving one or more conditioned spaces or thermal storage vessels.

Hydronic System, Geothermal Open-Loop. An open loop geothermal energy system draws in surface or ground water, passes it through one or more heat exchangers and/or heat pumps, and then discharges the water back into the environment.

Hydronic System, Non-Oxygen Barrier Closed-Loop. A hydronic system constructed all or in part with pipe or tubing that is not intended to restrict the diffusion of oxygen into the system fluid.

Hydronic System, Open-Loop System. A hydronic system where the fluid is enclosed in a piping system that is vented to the atmosphere, that takes in a fluid mass from an external source, transfers thermal energy into or out of the fluid by means of one or more heat exchangers, and then returns the fluid mass all or in part to an external source.

Hydronics. Of or relating to a heating or cooling system that transfers energy by circulating a fluid through a system of pipes or tubing.

211.0 – I –

Identified (as referenced to equipment and materials). Recognized as being suitable for the specific application, environment, function, installation, purpose, use, and so forth, where described in a particular code requirement.

Ignition Source. Appliances or equipment due to their intended use and operation, are capable of providing sufficient temperature and energy to raise its ignition temperature and capable of igniting flammable vapors or fumes. Sources may include appliance or equipment burners, burner igniters and electric switching devices.

Immersed Heat Exchanger. Heat exchanger, which is completely surrounded with the fluid in the storage tank.

Indirect Waste Pipe. A waste pipe that does not connect directly with the drainage system, but that discharges into the drainage system through an air break or air gap into a trap, fixture, receptor or interceptor.

Insolation. The rate of solar energy received on a unit surface in a unit time.

Instantaneous Efficiency. The amount of energy removed by the transfer fluid per gross collector area. During the specified time period, divided by the total solar radiation incident on the collector per unit area during the same test period, under steady state or quasi-steady state.

Integral Collector Storage. A solar thermal heating system that uses a solar collector that has all or most of its heat transfer liquid inside the collector.

Interactive System. An electric power production system that is operating in parallel with and capable of delivering energy to an electric primary source supply system. [NFPA 70:100]

Inverter. Equipment that changes dc to ac. [NFPA 70:100]

Inverter Input Circuit. Conductors connected to the dc input of an inverter. [NFPA 70:100]

Inverter Output Circuit. Conductors connected to the ac output of an inverter. [NFPA 70:100]

Inverter, Multimode. Equipment having the capabilities of both the interactive inverter and the stand-alone inverter. Inverter equipment capable of operating in both interactive and island modes. [NFPA 70:100]

Inverter, Stand-alone. Inverter equipment having the capabilities to operate only in island mode. [NFPA 70:100]

Irradiation, Instantaneous. The quantity of solar radiation incident on a unit surface area in unit time, measured in British thermal unit per square foot hour [Btu/(ft²•h)] (kW/m²).

Irradiation, Integrated Average. The solar radiation incident on a unit surface area during a specified time period divided by the duration of that time period.

212.0 – J –

Joint, Brazed. A joint obtained by joining of metal parts with alloys that melt at temperatures exceeding 840°F (449°C), but less than the melting temperature of the parts to be joined.

Joint, Compression. A multipiece joint with cup-shaped threaded nuts that, when tightened, compress tapered sleeves so that they form a tight joint on the periphery of the tubing they connect.

Joint, Flanged. One made by bolting together a pair of flanged ends.

Joint, Flared. A metal-to-metal compression joint in which a conical spread is made on the end of a tube that is compressed by a flare nut against a mating flare.

Joint, Heat Fusion. A joint used in some thermoplastic systems to connect the pipe to fittings or pipe lengths directly to one another (butt-fusion). This method of joining pipe to fittings includes butt-fusion, socket-fusion, electro-fusion, and saddle-fusion. This method of welding involves the application of heat and pressure to the components, allowing them to fuse together forming a bond between the pipe and fitting.

Joint, Mechanical. General form for gastight or liquid-tight joints obtained by the joining of parts through a positive holding mechanical construction.

Joint, Soldered. A joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at a temperature up to and including 840°F (449°C).

Joint, Welded. A gastight joint obtained by the joining of metal parts in the plastic molten state.

213.0 – K –

No definitions.

214.0 – L –

Labeled. Equipment or materials bearing a label of a listing agency (accredited conformity assessment body). See Listed (Third-Party Certified).
**Langelier Saturation Index.** A formula used to measure water balance or mineral saturation control of pool, spa, or hot tub water. Total alkalinity, calcium hardness, pH, water temperature, and total dissolved solids are measured, given a factor, and calculated to determine whether water has a tendency to be corrosive or scale forming.

**Langley (cal/ft²).** A unit of measurement of insolation, equal to 4.184 $\times 10^4$ joules per square meter ($J/m^2$).

**Listed (Third Party Certified).** Equipment or materials included in a list published by a listing agency (accredited conformity assessment body) that maintains periodic inspection on current production of listed equipment or material and whose listing states either that the equipment or material complies with approved standards or has been tested and found suitable for use in a specified manner.

**Listing Agency.** An agency accredited by an independent and authoritative conformity assessment body to operate a material and product listing and labeling (certification) system and that is accepted by the Authority Having Jurisdiction, which is in the business of listing and labeling. The system includes initial and ongoing product testing, a periodic inspection on current production of listed (certified) products, and that makes available a published report of such listing in which specific information is included that the material or product is in accordance with applicable standards and found safe for use in a specific manner.

**Load.** The heat output of the storage during discharge. The load is defined as the product of the mass flowrate, specific thermal capacity and temperature increase of the water or heat transfer fluid as it passes through a system.

**Low Hazard.** See Pollution.

**215.0 – M –**

**May.** A permissive term.

**Mechanical Code.** The mechanical code that is adopted by the jurisdiction. Where a mechanical code is not adopted or where the content of the mechanical code adopted by the jurisdictions is not applicable, then mechanical code shall mean the Uniform Mechanical Code (UMC) promulgated by the International Association of Plumbing and Mechanical Officials (IAPMO).

**216.0 – N –**

**Noncombustible Material.** As applied to building construction material, means a material that in the form in which it is used is either one of the following:

1. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E136 are considered noncombustible material.

2. Material having a structural base of noncombustible material as defined in (1) above, with a surfacing material not over $\frac{1}{3}$ of an inch (3.2 mm) thick that has a flame-spread index not higher than 50.

Noncombustible does not apply to surface finish materials. Material required to be noncombustible for reduced clearances to flues, heating appliances, or other sources of high temperature shall refer to material in accordance with 1 above. No material shall be classed as noncombustible that is subject to increase in combustibility or flame-spread index beyond the limits herein established, through the effects of age, moisture, or other atmospheric condition.

**Nuisance.** Includes, but is not limited to:

1. A public nuisance known at common law or in equity jurisprudence.

2. Where a work regulated by this code is dangerous to human life or detrimental to health and property.

3. Inadequate or unsafe water supply or sewage disposal system.

**217.0 – O –**

**Occupancy.** The purpose for which a building or part thereof is used or intended to be used.

**Offset.** A combination of elbows or bends in a line of piping that brings one section of the pipe out of line but into a line parallel with the other section.

**Out-Gassing.** As applied to thermal energy, the thermal process by which materials expel gas.

**Oxygen Permeation.** The ability of oxygen molecules to pass through a material. Also known as oxygen diffusion.

**218.0 – P –**

**Passive Solar Systems.** As used in these requirements, are solar systems that utilize elements of a building, without augmentation by mechanical components such as blowers or pumps, to provide for the collection, storage, or distribution of solar energy for heating, cooling, or both.

**PE.** Polyethylene.

**PE-AL-PE.** Polyethylene-aluminum-polyethylene.

**PE-RT.** Polyethylene of raised temperature.

**Person.** A natural person, his heirs, executor, administrators, or assigns and shall also include a firm, corporation, municipal or quasi-municipal corporation, or governmental agency. Singular includes plural, male includes female.

**PEX.** Cross-linked polyethylene.

**PEX-AL-PEx.** Cross-linked polyethylene-aluminum-cross-linked polyethylene.

**pH.** The log of the reciprocal of the hydrogen ion concentration of a solution, and a measure of the acidity or alkalinity of the water. It is determined by the concentration of hydrogen ions in a specific volume of water.

**Photolysis.** A chemical decomposition caused by radiation.

**Photosynthesis.** The building up of chemical compounds with the help of radiation.

**Photovoltaic.** Relating to electricity produced by the action of solar radiation on a solar cell.
DEFINITIONS

Photovoltaic Module. A complete, environmentally protected unit consisting of solar cells and other components designed to produce dc power. [NFPA 70:690.2100]

Photovoltaic Output Circuit. The dc circuit conductors from two or more connected PV source circuits to their point of termination. [NFPA 70:690.2]

Photovoltaic Source Circuit. The PV dc circuit conductors between modules in a PV string circuit, and from PV string circuits or dc combiners, to dc combiners, electronic power converters, or a dc PV system disconnecting means. [NFPA 70:690.2100]

Photovoltaic String Circuit. The PV source circuit conductors of one or more series-connected PV modules. [NFPA 70:100]

Photovoltaic System DC Circuit. Any dc conductor in PV source circuits, PV output string circuits, and PV dc-to-dc converter source circuits, and dc-to-dc converter output circuits. [NFPA 70:690.2100]

Photovoltaic Thermal System (PVT). A hybrid system which incorporates a heating or cooling solar thermal system in combination with a solar photovoltaic system to generate both electrical and thermal energy. These systems are designed to improve system efficiency and simultaneously produce or reject thermal energy.

Pipe. A cylindrical conduit or conductor conforming to the particular dimensions commonly known as “pipe size.”

Piping. The pipe or tube mains for interconnecting the various parts of a system. Piping includes pipe, tube, flanges, bolting, gaskets, valves, fittings, the pressure-containing parts of other components such as expansion joints, strainers, and devices that serve such purposes as mixing, separating, snubbing, distributing, metering, or controlling flow, pipe-supporting fixtures and structural attachments.

Plastic CC1. Plastic materials that have a burning extent of 1 inch (25.4 mm) or less where tested in nominal 0.060 of an inch (1.52 mm) thickness by ASTM D635 or in the thickness intended for use.

Plastic CC2. Plastic materials that have a burning rate of 150 inches per hour (in/h) (63.5 mm/min) or less where tested in nominal 0.060 inch (1.52 mm) thickness by ASTM D635 or in the thickness intended for use.

Plenum. An air compartment or chamber to which one or more ducts are connected and that forms part of either the conditioned air supply, circulating air, or exhaust air system, other than the occupied space being conditioned.

Plumbing Code. The plumbing code that is adopted by the jurisdiction. Where a plumbing code is not adopted or where the content of the plumbing code adopted by the jurisdiction is not applicable, then plumbing code shall mean the Uniform Plumbing Code (UPC) promulgated by the International Association of Plumbing and Mechanical Officials (IAPMO).

Pollution. An impairment of the quality of the potable water to a degree that does not create a hazard to the public health but which does adversely and unreasonably affect the aesthetic qualities of such potable water for domestic use. Also defined as Low Hazard.

Potable Water. Water that is satisfactory for drinking, culinary, and domestic purposes and that meets the requirements of the Health Authority Having Jurisdiction.

Pressure. The normal force exerted by a homogeneous liquid or gas, per unit of area, on the wall of the container.

Pressure, Residual. The pressure available at the fixture or water outlet after allowance is made for pressure drop due to friction loss, head, meter, and other losses in the system during maximum demand periods.

Pressure, Static. The pressure existing without any flow.

Pressure-Limiting Device. A pressure-responsive mechanism designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

Pressure Test. The minimum gauge pressure to which a specific system component is subjected under test condition.

PVC. Polyvinyl Chloride.

Pyranometer. A device used to measure the total solar radiation incident upon a surface per unit time per unit area.

Pyrheliometer. A device used to measure the direct radiation on a surface normal to the sun’s rays.

219.0 – Q –

Quasi-Steady State. The state of the solar collector where the flow rate and temperature of the fluid entering the collector are constant but the exit fluid temperature changes gradually due to the normal change in irradiation that occurs with time for clear sky conditions.

Quick-Acting Valve. A valve that closes quickly or abruptly where manually released or electrically actuated.

220.0 – R –

Radiant Heater. A heater designed to transfer heat primarily by direct radiation.

Registered Design Professional. An individual who is registered or licensed by the laws of the state to perform such design work in the jurisdiction.

Relief Valve, Vacuum. A device which automatically opens or closes for relieving a vacuum with the system, depending on whether the vacuum is above or below a predetermined value.

Rock Storage. A bin, basement, or other container filled with rock to act as an energy reservoir for a solar system.

221.0 – S –

Selective Surface. A special coating applied to solar collectors, having high absorption and low emission factors.

Shall. Indicates a mandatory requirement.

Six-Pipe Heat Pump System. A hydronic system capable of simultaneously heating and cooling. The first four pipes within these systems enable simultaneous heating and cooling while the additional two pipes are typically connected to a
source and/or sink to either add or reject energy to the system. Dependent upon the equipment, such systems may comingle the source and load fluids.

**Size.** See Diameter.

**Solar Cell.** The basic PV photovoltaic device that generates dc electricity when exposed to light. [NFPA 70:100]

**Solar Collector.** A device used to absorb energy from the sun.

**Solar Constant.** The average amount of solar radiation reaching the earth’s atmosphere per unit time [about 2 langleys per minute [1395 J/(m²•s)].

**Solar Energy System.** A configuration of equipment and components to collect, convey, store, and convert the sun’s energy for a purpose.

**Solar Energy System Components.** Any appliance, assembly, device, equipment, or piping used in the conversion of solar energy into thermal energy for service water heating, pool water heating, space heating and cooling, and electrical service.

**Solar Thermal System.** A complete assembly of subsystems which convert solar energy into thermal energy and utilize this energy for service water heating, pool water heating, space heating and cooling purposes.

**Stand-Alone System.** A system that is capable of supplying power independent of not connected to an electric power production and distribution network. [NFPA 70:100]

**Standard.** A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine print note and are not to be considered a part of the requirements of a standard.

**Standard Air.** Air weighing 0.075 of a pound per cubic foot (lb/ft³) (1.20 kg/m³) and is equivalent in density to dry air at a temperature of 70°F (21°C) and standard barometric pressure of 29.92 inches of mercury (inHg) (101.3 kPa).

**Storage Tank.** See Thermal Storage.

**Storage Temperature.** Temperature of the storage medium.

**Stored Energy.** Accumulated energy that is available for use.

**Stratified.** State where thermal stratification is inside the storage.

**Submerged Heat Exchanger.** A closed-loop heat exchanger submerged in water or a fluid. Some examples include, but are not limited to, lake or pond heat exchangers, sanitary waste heat recovery systems, downhole heat exchangers, and standing column well heat exchangers.

**Supports.** Supports, hangers, and anchors are devices for properly supporting and securing pipe, fixtures, and equipment.

**System Coefficient of Performance (SCOP).** A ratio of the total system energy moved to the total system purchased energy.

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**DEFINITIONS**

222.0 – T –

**Termination, Duct.** The final or intended end-portion of a duct system that is designed and functions to fulfill the obligations of the system in a satisfactory manner. [NFPA 96:3.3.19]

**Thermal Energy.** The amount of sensible heat energy stored within a material or fluid. The product of the mass, specific thermal capacity and temperature increase/decrease of the material or fluid. Also known as sensible heat energy.

**Thermal Highway.** A collection of one or more geothermal micro-districts that acts as an energy transport system and supplies or accepts energy from multiple geothermal micro-districts, individual buildings, or other sources. Also known as convective circulation circuit.

**Thermal Resources.** A source for heating and a sink for cooling. There are two types of sources:

1. **Conventional-type:** such systems are known as geothermal energy systems, including air-source resources and ground-source resources.

2. **Opportunist-type:** such systems use water-source resources (e.g., oceans, rivers, raw sewage pipes, treated sewage outfall, potable water pipes, etc.), process byproduct heat resources (e.g., data center cooling process reject heat, industrial process reject heat, etc.), and other resources.

**Thermal Storage.** A tank or vessel used in a solar thermal, hydronic, or geothermal system, in which thermal energy is stored.

**Thermal Stratification.** State where the local storage temperature is a function of the vertical storage height, with the temperature decreasing from top to bottom.

**Thermosiphon.** The natural circulation of fluids due to temperature differential.

**Tilt Angle.** The angle above horizontal of a plane surface.

**Time Constant.** The time required for the fluid leaving a solar collector to attain 63.2 percent of its steady state value following a step change in insolation or inlet fluid temperature.

**Total Alkalinity.** The sum of all alkaline minerals in the water that is primarily in bicarbonate form, but also as sodium, calcium, magnesium, potassium carbonates, and hydroxides. It is a measure of the water’s ability to resist changes in pH.

**Total Dissolved Solids (TDS).** A measure (by electrical conductivity) of the amount of soluble matter that is present in the water.

**Total Incident Irradiation.** The total solar radiant energy incident upon a unit surface area during a specified time period expressed in British thermal unit per square foot (Btu/ft²) (J/m²).

**Transfer System.** The intermediate piping, ducts, or both between the various components of the solar system.

**Transfer Time.** Time period during which energy is transferred through the connections for charge (x=C) or discharge.
The transfer time is calculated over one of more test sequences, excluding time periods used for conditioning at the beginning of the test sequences.

**Trickling Collector.** A solar collector in which fluids free flow over the collector surface.

223.0  –  U  –
No definitions.

224.0  –  V  –
**Valve, Pressure-Relief.** A pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting.

**Venetian Blind Collector.** A solar collector in which movable vanes are employed to absorb or reject energy.

225.0  –  W  –
**Water-Distribution Pipe.** In a building or premises, a pipe that conveys potable water from the building supply pipe to the plumbing fixtures and other water outlets.

**Water Hammer.** A hydraulic shock that occurs within a pressurized piping system resulting from a pressure surge propagating through the piping system when fluid flow abruptly changes velocity or direction, when the fluid flow within the system is suddenly stopped and the fluid momentum is broken.

**Water Supply System.** The building supply pipe, the water-distribution pipes, and the necessary connecting pipes, fittings, control valves, backflow prevention devices, and all appurtenances carrying or supplying potable water in or adjacent to the building or premises.

**Water Well.** An excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed for the purposes of extracting groundwater, using the geothermal properties of the earth or injecting water into an aquifer or subsurface reservoir.

226.0  –  X  –
No definitions.

227.0  –  Y  –
No definitions.

228.0  –  Z  –
No definitions.
CHAPTER 3
GENERAL REGULATIONS

301.0 General.
301.1 Applicability. This chapter shall govern the general requirements for the installation, design, construction, and repair of a solar energy, hydronic, or geothermal system.

302.0 Standards and Alternates.
302.1 Minimum Standards. Pipe, pipe fittings, appliances, appurtenances, equipment, material, and devices used shall be listed (third party certified) by a listing agency (accredited conformity assessment body) as complying with the approved applicable recognized standards referenced in this code, and shall be free from defects. Unless otherwise provided for in this code, materials, appurtenances, or devices used or entering into the construction of a system, or parts thereof, shall be submitted to the Authority Having Jurisdiction for approval.

302.1.1 Marking. Each length of pipe and each pipe fitting, material, and device used shall have cast, stamped, or indelibly marked on it any markings required by the applicable referenced standards and listing agency, and the manufacturer’s mark or name, which shall readily identify the manufacturer to the end user of the product. Where required by the approved standard that applies, the product shall be marked with the weight and the quality of the product. Materials and devices used or entering into the construction of a system, or parts thereof shall be marked and identified in a manner satisfactory to the Authority Having Jurisdiction. Such marking shall be done by the manufacturer. Field markings shall not be acceptable.

Exception: Markings shall not be required on nipples created from cutting and threading of approved pipe.

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.

302.1.3 Existing Buildings. In existing buildings or premises in which system installations are to be altered, repaired, or renovated, the Authority Having Jurisdiction has discretionary powers to permit deviation from the provisions of this code, provided that such proposal to deviate is first submitted for proper determination in order that health and safety requirements, as they pertain to the system, shall be observed.

302.2 Alternate Materials and Methods of Construction Equivalency. Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire-resistance, effectiveness, durability, and safety over those prescribed by this code. Technical documentation shall be submitted to the Authority Having Jurisdiction to demonstrate equivalency. The Authority Having Jurisdiction shall have the authority to approve or disapprove the system, method, or device for the intended purpose.

However, the exercise of this discretionary approval by the Authority Having Jurisdiction shall have no effect beyond the jurisdictional boundaries of said Authority Having Jurisdiction. An alternate material or method of construction so approved shall not be considered as in accordance with the requirements, intent, or both of this code for a purpose other than that granted by the Authority Having Jurisdiction where the submitted data does not prove equivalency.

302.2.1 Testing. The Authority Having Jurisdiction shall have the authority to require tests, as proof of equivalency.

302.2.1.1 Tests. Tests shall be made in accordance with approved or applicable standards, by an approved testing agency at the expense of the applicant. In the absence of such standards, the Authority Having Jurisdiction shall have the authority to specify the test procedure.

302.2.1.2 Request by Authority Having Jurisdiction. The Authority Having Jurisdiction shall have the authority to require tests to be made or repeated where there is a reason to believe that a material or device no longer is in accordance with the requirements on which its approval was based.

302.3 Flood Hazard Areas. Systems shall be located above the elevation in accordance with the building code for utilities and attendant equipment or the elevation of the lowest floor, whichever is higher.

Exception: Systems shall be permitted to be located below the elevation in accordance with the building code for utilities and attendant equipment or the elevation of the lowest floor, whichever is higher, provided that the systems are designed and installed to prevent water from entering or accumulating within their components and the systems are constructed to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to such elevation.

302.3.1 Coastal High Hazard Areas. Systems in buildings located in coastal high hazard areas shall be in accordance with the requirements of Section 302.3, and
systems, pipes, tubing, and appurtenances shall not be mounted on or penetrate through walls that are intended to breakaway under flood loads in accordance with the building code.

302.3.2 Flood Resistant Materials. System components installed in flood hazard areas and below the design flood elevation shall be made of flood damage-resistant materials.

302.4 Alternative Engineered Design. An alternative engineered design shall comply with the intent of the provisions of this code and shall provide an equivalent level of quality, strength, effectiveness, fire resistance, durability, and safety. Material, equipment, or components shall be designed and installed in accordance with the manufacturer’s installation instructions.

302.4.1 Permit Application. The registered design professional shall indicate on the design documents that the system, or parts thereof, is an alternative engineered design so that it is noted on the construction permit application. The permit and permanent permit records shall indicate that an alternative engineered design was part of the approved installation.

302.4.2 Technical Data. The registered design professional shall submit sufficient technical data to substantiate the proposed alternative engineered design and to prove that the performance meets the intent of this code.

302.4.3 Design Documents. The registered design professional shall provide two complete sets of signed and sealed design documents for the alternative engineered design for submittal to the Authority Having Jurisdiction. The design documents shall include floor plans of the work. Where appropriate, the design documents shall indicate location, sizing, and loading of appurtenances, equipment, appliances, and devices.

302.4.4 Design Approval. An approval of an alternative engineered design shall be at the discretion of the Authority Having Jurisdiction. The exercise of this discretionary approval by the Authority Having Jurisdiction shall have no effect beyond the jurisdictional boundaries of said Authority Having Jurisdiction. An alternative engineered design so approved shall not be considered as in accordance with the requirements, intent, or both of this code for a purpose other than that granted by the Authority Having Jurisdiction.

302.4.5 Design Review. The Authority Having Jurisdiction shall have the authority to require testing of the alternative engineered design in accordance with Section 302.2.1, including the authority to require an independent review of the design documents by a registered design professional selected by the Authority Having Jurisdiction and at the expense of the applicant.

302.4.6 Inspection and Testing. The alternative engineered design shall be tested and inspected in accordance with the submitted testing and inspection plan and the requirements of this code.

303.0 Iron Pipe Size (IPS) Pipe.

303.1 General. Iron, steel, brass, and copper pipe shall be standard-weight iron pipe size (IPS) pipe.

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 for repair or replacement of the appliance. Sufficient clearance shall be maintained to permit removal of the appliance; 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 in accordance with Section 304.3.

Unless otherwise specified, clearances of not less than 30 inches (762 mm) in depth, width, and height of working space shall be provided maintained.

Exception: A platform shall not be required for unit heaters or room heaters.

304.2 Access to Appliances on Roofs. Appliances located on roofs or other elevated locations shall be accessible. [NFPA 54:9.4.3.1]

304.2.1 Access. Buildings exceeding more than 15 feet (4572 mm) in height shall have an inside means of access to the roof, unless other means acceptable to the Authority Having Jurisdiction are used.

Exception: In Group R occupancies of less than 6 dwelling units and Group U occupancies. [NFPA 54:9.4.3.2]

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]

304.2.3 Permanent Ladders. Permanent ladders required by Section 304.2.2 shall be constructed in accordance with the following:

(1) Side railings shall extend not less than 30 inches (762 mm) above the roof or parapet wall.

(2) Landings shall not exceed 18 feet (5486 mm) apart measured from the finished grade.

(3) Width shall be not less than 14 inches (356 mm) on center.
304.4 Appliances on Roofs. Appliances on roofs shall be designed or enclosed so as to withstand climatic conditions in the area in which they are installed. Where enclosures are provided, each enclosure shall permit easy entry and movement, shall be of reasonable height, and shall have at least a 30 inch (762 mm) clearance between the entire service access panel(s) of the appliance and the wall of the enclosure. [NFPA 54:9.4.1.1]

304.4.1 Load Capacity. Roofs on which appliances are to be installed shall be capable of supporting the additional load or shall be reinforced to support the additional load. [NFPA 54:9.4.1.2]

304.4.2 Fasteners. All access locks, screws, and bolts shall be of corrosion-resistant material. [NFPA 54:9.4.1.3]

304.4.3 Installation of Appliances on Roofs. Appliances shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:9.4.2.1]

304.4.4 Clearance. Equipment and appliances shall be installed on a well-drained surface of the roof. Not less than 6 feet (1829 mm) of clearance shall be between a part of the equipment or appliance and the edge of a roof or similar hazard, or rigidly fixed rails, guards, parapets, or other building structures not less than 42 inches (1067 mm) in height shall be provided on the exposed side. Clearance requirements shall not apply to solar equipment.

304.4.5 Electrical Power. Appliances requiring an external source of electrical power shall be installed in accordance with NFPA 70. [NFPA 54:9.4.2.3]

304.4.6 Platform or Walkway. Where water stands on the roof at the appliance or in the passageways to the appliance, or where the roof is of a design having a water seal, a suitable platform, walkway, or both shall be provided above the water line. Such platform(s) or walkway(s) shall be located adjacent to the appliance and control panels so that the appliance can be safely serviced where water stands on the roof. [NFPA 54:9.4.2.4]

305.0 Installation.

305.1 Listed Appliances. Except as otherwise provided in this code, the installation of appliances regulated by this code shall be in accordance with the conditions of the listing. The appliance installer shall leave the manufacturer’s installation and operating instructions attached to the appliance. Clearances of listed appliances from combustible materials shall be as specified in the listing or on the rating plate.

305.2 Dissimilar Metals. Except for necessary valves, where intermembering or mixing of dissimilar metals occur, the point of connection shall be confined to exposed or accessible locations.

The Authority Having Jurisdiction shall be permitted to require the use of an approved dielectric insulator on the piping connections of an open loop system.

305.3 Direction of Flow. Valves, pipes, and fittings shall be installed in correct relationship to the direction of flow.

305.4 Changes in Direction. Changes in direction shall be made by the approved use of fittings, except that changes in direction in copper tubing shall be permitted to be made with bends provided that such bends are made with bending equipment that does not deform or create a loss in the cross-sectional area of the tubing.

305.5 Improper Location. Piping or equipment shall not be located as to interfere with the normal use thereof or with the normal operation and use of windows, doors, or other required facilities.

305.6 Insulation. Piping, tubing, and fittings shall be insulated where located in areas capable of reaching a surface...
temperature below the dew point of the surrounding air and located in spaces or areas where condensation is capable of creating a hazard for the building occupants or damage to the structure.

305.7 Drainage Pan. Where a water heater, boiler, or thermal storage tank is located in an attic, or in or on an attic-ceiling assembly, floor-ceiling assembly, or floor subfloor assembly where damage results from a leaking water heater, boiler, or tank, a watertight pan of corrosion-resistant materials shall be installed beneath the water heater, boiler, or tank, with not less than 1/4 of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than 1 1/2 inches (38 mm) in depth.

305.8 Anchorage. Appliances and equipment designed to be fixed in position shall be securely fastened in place in accordance with the manufacturer’s installation instructions. The supports shall be designed and constructed to sustain vertical and horizontal loads within the stress limitations specified in the building code.

305.9 Structural Design Loads. System components, including building components and attachments, shall be designed and constructed to withstand the following loads in accordance with the building code:

1. Dead loads
2. Live loads
3. Snow loads
4. Wind loads
5. Seismic loads
6. Flood loads
7. Expansion and contraction loads resulting from temperature changes

305.10 Location. Except as otherwise provided in this code, no system, or parts thereof, shall be located in a lot other than the lot that is the site of the building, structure, or premises served by such facilities.

305.11 Ownership. No subdivision, sale, or transfer of ownership of existing property shall be made in such manner that the area, clearance, and access requirements of this code are decreased.

306.0 Workmanship.

306.1 Engineering Practices. Design, construction, and workmanship shall comply with accepted engineering practices and shall be of such character as to secure the results sought to be obtained by this code.

306.2 Concealing Imperfections. It is unlawful to conceal cracks, holes, or other imperfections in materials by welding, brazing, or soldering or by using therein or thereon a paint, wax, tar, solvent cement, or other leak-sealing or repair agent.

306.3 Burried Ends. Burried ends of pipe and tubing shall be reamed to the full bore of the pipe or tube, and chips shall be removed.

306.4 Installation Practices. A system shall be installed in a manner that is in accordance with this code, applicable standards, and the manufacturer’s installation instructions.

306.4.1 On-Site. The installer shall leave the manufacturer’s installation and operating instructions with the system owner.

307.0 Labeling.

307.1 Fuel-Burning Appliances. Fuel-burning heating appliances shall bear a permanent and legible factory applied nameplate on which shall appear:

1. The name or trademark of the manufacturer.
2. The approved fuel input rating of the appliance, expressed in Btu/h (kW).
3. The model number or equivalent.
4. The serial number.
5. Instructions for the lighting, operation, and shutdown of the appliance.
6. The type of fuel approved for use with the appliance.
7. The symbol of an approved agency certifying compliance of the equipment with recognized standards.
8. Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.

307.2 Electric Heating Appliances. Electric heating appliances shall bear a permanent and legible factory applied nameplate on which shall appear:

1. The name or trademark of the manufacturer.
2. The model number or equivalent.
3. The serial number.
4. The electrical rating in volts, amperes (or watts), and, for other than single phase, the number of phases.
5. The output rating in Btu/h (kW).
6. The electrical rating in volts, amperes, or watts of each field-replaceable electrical component.
7. The symbol of an approved agency certifying compliance of equipment with recognized standards.
8. Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.

An appliance shall be accompanied by clear and complete installation instructions, including required clearances from combustibles other than mounting or adjacent surfaces, and temperature rating of field-installed wiring connections exceeding 140°F (60°C).

307.3 Heat Pump and Electric Cooling Appliances. Heat pumps and electric cooling appliances shall bear a permanent and legible factory-applied nameplate on which shall appear:

1. The name or trademark of the manufacturer.
2. The model number or equivalent.
3. The serial number.
4. The amount and type of refrigerant.
5. The factory test pressures or pressures applied.
6. The electrical rating in volts, amperes, and, for other than single phase, the number of phases.
7. The output rating in Btu/h (kW).
(8) The electrical rating in volts, amperes, or watts of each field replaceable electrical component.
(9) The symbol of an approved agency certifying compliance of the equipment with recognized standards.
(10) Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.

An appliance shall be accompanied by clear and complete installation instructions, including required clearances from combustible other than mounting or adjacent surfaces, and temperature rating of field-installed wiring connections exceeding 140°F (60°C).

307.4 Absorption Units. Absorption units shall bear a permanent and legible factory-applied nameplate on which shall appear:
(1) The name or trademark of the manufacturer.
(2) The model number or equivalent.
(3) The serial number.
(4) The amount and type of refrigerant.
(5) Hourly rating in Btu/h (kW).
(6) The type of fuel approved for use with the unit.
(7) Cooling capacity Btu/h (kW).
(8) Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.
(9) The symbol of an approved agency certifying compliance of the equipment with recognized standards.

308.0 Condensate Waste and Control.
308.1 Condensate Disposal. Condensate from air washers, air-cooling coils, condensing appliances, and the overflow from evaporative coolers and similar water supplied equipment or similar air-conditioning equipment shall be collected and discharged to an approved plumbing fixture or disposal area. Where discharged into the drainage system, equipment shall drain using an indirect waste pipe. The waste pipe shall have a slope of not less than ½ inch per foot (10.4 mm/m) or 1 percent slope and shall be of approved corrosion-resistant material not smaller than the outlet size in accordance with Section 308.1. An additional protection method for condensate overflow shall be provided in accordance with one of the following:
(1) A water level detecting device that will shut off the equipment or appliance in the event the primary drain is blocked.
(2) An additional watertight pan of corrosion-resistant material, with a separate drain line, installed beneath the cooling coil, unit, or the appliance to catch the overflow condensate due to a clogged primary condensate drain.
(3) An additional drain line at a level that is higher than the primary drain line connection of the drain pan.
(4) An additional watertight pan of corrosion-resistant material with a water level detection device installed beneath the cooling coil, unit, or the appliance to catch the overflow condensate due to a clogged primary condensate drain and to shut off the equipment.

The additional pan or the additional drain line connection shall be provided with a drain pipe of not less than ¾ of an inch (20 mm) nominal pipe size, discharging at a point that is readily observed.

308.2 Condensate Control. Where an equipment or appliance is installed in a space where damage is capable of resulting from condensate overflow, other than damage to replaceable lay-in ceiling tiles, a drain line shall be provided and shall be drained in accordance with Section 308.1. An additional protection method for condensate overflow shall be provided in accordance with one of the following:
(1) A water level detecting device that will shut off the equipment or appliance in the event the primary drain is blocked.
(2) An additional watertight pan of corrosion-resistant material, with a separate drain line, installed beneath the cooling coil, unit, or the appliance to catch the overflow condensate due to a clogged primary condensate drain.
(3) An additional drain line at a level that is higher than the primary drain line connection of the drain pan.
(4) An additional watertight pan of corrosion-resistant material with a water level detection device installed beneath the cooling coil, unit, or the appliance to catch the overflow condensate due to a clogged primary condensate drain and to shut off the equipment.

The additional pan or the additional drain line connection shall be provided with a drain pipe of not less than ¾ of an inch (20 mm) nominal pipe size, discharging at a point that is readily observed.

308.2.1 Protection of Appurtenances. Where insulation or appurtenances are installed where damage is capable of resulting from a condensate drain pan overfill, such installations shall occur above the rim of the drain pan with supports. Where the supports are in contact with the condensate waste, the supports shall be of approved corrosion-resistant material.

308.3 Condensate Waste Pipe Material and Sizing. Condensate waste pipes from air-cooling coils shall be sized in accordance with the equipment capacity as specified in Table 308.3. The material of the piping shall comply with the pressure and temperature rating of the appliance or equipment, and shall be approved for use with the liquid being discharged.

<table>
<thead>
<tr>
<th>EQUIPMENT CAPACITY IN TONS OF REFRIGERATION</th>
<th>MINIMUM CONDENSATE PIPE DIAMETER (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 20</td>
<td>¾</td>
</tr>
<tr>
<td>21 – 40</td>
<td>1</td>
</tr>
<tr>
<td>41 – 90</td>
<td>1½</td>
</tr>
<tr>
<td>91 – 125</td>
<td>1½</td>
</tr>
<tr>
<td>126 – 250</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI units: 1 ton of refrigeration = 3.52 kW, 1 inch = 25 mm

The size of condensate waste pipes is for one unit or a combination of units, or as recommended by the manufac-
turer. The capacity of waste pipes assumes a ½ inch per foot (10.4 mm/m) or 1 percent slope, with the pipe running three-quarters full at the following pipe conditions:

<table>
<thead>
<tr>
<th>Outside Air – 20%</th>
<th>Room Air – 80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB</td>
<td>WB</td>
</tr>
<tr>
<td>90°F</td>
<td>73°F</td>
</tr>
<tr>
<td>75°F</td>
<td>62.5°F</td>
</tr>
</tbody>
</table>

Condensate drain sizing for other slopes or other conditions shall be approved by the Authority Having Jurisdiction.

308.3.1 Cleanouts. Condensate drain lines shall be configured or provided with a cleanout to permit the clearing of blockages and for maintenance without requiring the drain line to be cut.

308.4 Appliance Condensate Drains. Condensate drain lines from individual condensing appliances shall be sized as required by the manufacturer’s instructions. Condensate drain lines serving more than one appliance shall be approved by the Authority Having Jurisdiction prior to installation.

308.5 Point of Discharge. Air-conditioning condensate waste pipes shall connect indirectly, except where permitted in Section 308.6, to the drainage system through an air gap or air break to trapped and vented receptors, dry wells, leach pits, or the tailpiece of plumbing fixtures. A condensate drain shall be trapped in accordance with the appliance manufacturer’s instructions or as approved.

308.6 Condensate Waste from Air-Conditioning Coils. Where the condensate waste from air conditioning coils discharges by direct connection to a lavatory tailpiece or to an approved accessible inlet on a bathtub overflow, the connection shall be located in the area controlled by the same person controlling the air-conditioned space.

308.7 Plastic Fittings. Female plastic screwed fittings shall be used with male plastic fittings and plastic threads.

309.0 Safety Requirements.

309.1 Welding. Welding shall be done by approved welders in accordance with nationally recognized standards. Such welding shall be subject to the approval of the Authority Having Jurisdiction.

309.2 Spark or Flame. Equipment that generates a glow, spark, or flame capable of igniting flammable vapors shall be permitted to be installed in a residential garage provided the pilots and burners, heating elements, motors, controllers, or switches are not less than 18 inches (457 mm) above the floor level unless listed as flammable vapor ignition resistant.

309.3 Hazardous Heat-Transfer Mediums. Heat-transfer mediums that are hazardous shall not be used, except where approved by the Authority Having Jurisdiction.

309.4 Discharge. The collector, collector manifold, and manifold relief valve shall not discharge directly or indirectly into the building or toward an open flame or other source of ignition.

310.0 Circulators and Pumps.

310.1 General. Circulators and pumps shall be selected for their intended use based on the heat transfer fluid, intended operating temperature range and pressure. Circulators and pumps shall be installed to allow for service and maintenance. The manufacturer’s installation instructions shall be followed for correct orientation and installation. Motor operated pumps rated 600V or less shall be listed and labeled in accordance with UL 778.

310.2 Mounting. The circulator or pump shall be installed in such a way that strain from the piping is not transferred to the circulator or pump housing. The circulator or pump shall be permitted to be directly connected to the piping, provided the piping is supported on each side of the circulator or pump. Where the installation of a circulator or pump will cause strain on the piping, the circulator or pump shall be installed on a mounting bracket or base plate or securely fastened to or supported by the structure with approved fastening devices. Where means for controlling vibration of a circulator or pump is required, an approved means for support and restraint shall be provided.

310.3 Sizing. The selection and sizing of a circulator or pump shall be based on the following:

- (1) Loop or system head pressure, feet of head (m)
- (2) Capacity, gallons per minute (L/s)
- (3) Maximum and minimum temperature, °F (°C)
- (4) Maximum working pressure, pounds-force per square inch (kPa)
- (5) Fluid type

310.4 Drainback Systems. For drainback solar thermal systems, a circulator without a check valve shall be installed.

310.5 Pumps Used in Parallel. A check valve shall be installed downstream of each circulator installed in parallel. Circulators with integral check valves shall be installed.

310.6 Cavitation. Systems, which utilize circulators, shall be designed such that the pressure of the system is more than the vapor pressure of the liquid it conveys.

310.7 Materials. Circulating pumps shall be constructed of materials that are compatible with the heat transfer medium.

310.8 Operation. Over-temperature protection shall be provided for circulating pumps. The temperature set point of the pump shall comply with the manufacturer’s instructions. The pumps shall automatically turn off when the system is not in operation.

311.0 Safety Devices.

311.1 General. Solar thermal system components containing pressurized fluids shall be protected against pressures exceed-
ing the design limitations with a pressure relief valve. Hydronic or geothermal system components containing pressurized fluids shall be protected against pressures exceeding design limitations with a pressure 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 relief valves shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

311.2 Pressurized Vessels. Pressurized vessels shall be provided with overpressure protection by means of a listed pressure relief valve installed in accordance with the manufacturer’s installation instructions.

311.3 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall have no valves, obstructions, or means of isolation and be provided with the following:

(1) Not less than the size of the valve outlet and shall discharge full size to the flood level of the area receiving the discharge and pointing down.

(2) Materials shall be rated at not less than the operating temperature of the system and approved for such use or shall comply with ASME A112.4.1.

(3) Discharge pipe shall discharge independently by gravity through an air gap into the drainage system or outside of the building with the end of the pipe not exceeding 2 feet (610 mm) and not less than 6 inches (152 mm) above the ground and pointing downwards.

(4) Discharge in such a manner that does not cause personal injury or structural damage.

(5) No part of such discharge pipe shall be trapped or subject to freezing.

(6) The terminal end of the pipe shall not be threaded.

(7) Discharge from a relief valve into a water heater pan shall be prohibited.

(8) The discharge termination point shall be readily observable.

311.4 Vacuum Relief Valves. System components that are subjected to a vacuum while in operation or during shutdown shall be protected with vacuum relief valves. Where the piping configuration, equipment location, and valve outlets are located below the storage tank elevation, the system shall be equipped with a vacuum relief valve at the highest point.

311.5 Temperature Regulation. Where a system is capable of providing potable water at temperatures that exceed 140°F (60°C), a thermostatic mixing valve that is in accordance with ASSE 1017 shall be provided to limit the water supplied to the potable hot water distribution system to a temperature of 140°F (60°C) or less.

312.0 Valves.

312.1 General. Valves shall be rated for the operating temperature and pressure of the system. Valves shall be compatible with the type of heat transfer medium and piping material.

312.2 Where Required. Valves shall be installed in a solar thermal, hydronic, or geothermal system in accordance with Section 312.3 through Section 312.15.

312.3 Heat Exchanger. Isolation valves shall be installed on the supply and return side of the heat exchanger.

312.4 Pressure Vessels. Isolation valves shall be installed on connections to pressure vessels.

312.5 Pressure Reducing Valves. Isolation valves shall be installed on both sides of a pressure reducing valve.

312.6 Equipment, Components, and Appliances. Serviceable equipment, components, and appliances within the system shall have isolation valves installed upstream and downstream of such devices.

312.7 Expansion Tanks. Isolation valves shall be installed at connections to non-diaphragm-type expansion tanks.

312.8 Flow Balancing Valves. Where flow balancing valves are installed, such valves shall be capable of increasing or decreasing the amount of flow by means of adjustment.

312.9 Control Valves. An approved three-way valve shall be permitted to be installed for manual control systems. An approved electric control valve shall be permitted to be installed for automatic control systems. The installation and operation of automatic control valves shall comply with the manufacturer’s instructions.

312.9.1 Mixing or Temperature Control Valves. Where mixing or temperature control valves are installed, such valves shall be capable of obtaining the design water temperature and design flow requirements.

312.10 Thermosiphoning. An approved type check valve shall be installed on hydronic piping to control thermosiphoning of heated fluids.

312.11 Air Removal Device or Air Vents. Isolation valves shall be installed where air removal devices or automatic air vents are utilized to permit cleaning, inspection, or repair without shutting the system down.

312.12 District Energy and Central Utility Systems. Isolation valves shall be accessible and shall be installed on each building supply and return of a district energy or central utility system.

312.13 Closed-Loop Systems. Closed-loop systems, where hose bibbs or similar valves are used to charge or drain the system, shall be of loose key type; have valve outlets capped; or have handles removed where the system is operational.

312.14 Fullway Valves. A fullway valve shall be installed in the following locations:

(1) On the water supply to a solar thermal system.
(2) On the water supply pipe to a gravity or pressurized water tank.
(3) On the water supply pipe to a water heater.

312.15 Accessible. Required fullway or shutoff valves shall be accessible.

313.0 Heat Exchangers.
313.1 General. Systems utilizing heat exchangers shall protect the potable water system from being contaminated by the heat transfer medium. Systems that incorporate a single-wall heat exchanger to separate potable water from the heat transfer fluid shall meet the following requirements:
(1) Heat transfer medium is either potable water or contains fluids recognized as safe by the Food and Drug Administration (FDA) as food grade.
(2) A tag or label shall be securely affixed to the heat source with the word “CAUTION” and the following statements:
   (a) The heat transfer medium shall be water or other nontoxic fluid recognized as safe by the FDA.
   (b) The maximum operating pressure of the heat exchanger shall not exceed the maximum operating pressure of the potable water supply.
(3) The word “CAUTION” and the statements listed above shall have an uppercase height of not less than 0.120 of an inch (3.05 mm). The vertical spacing between lines of type shall be not less than 0.046 of an inch (1.168 mm). Lowercase letters shall be not less than compatible with the uppercase letter size specification.

Systems that do not comply with the requirements for a single-wall heat exchanger shall install a double-wall heat exchanger. Double-wall heat exchangers shall separate the potable water from the heat transfer medium by providing a space between the two walls that are vented to the atmosphere.

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.

314.0 Unlawful Connections.
314.1 Prohibited Installation. No piping installation, or part thereof, shall be made in such a manner that it will be possible for used, unclean, polluted, or contaminated water, mixtures, or substances to enter a portion of the potable water system from a pipe, tank, receptor, or equipment by reason of backsiphonage, suction, or other cause, either during normal use and operation thereof, or where such pipe, tank, receptor, or equipment is subject to pressure exceeding the operating pressure in the potable water system.

315.0 Electrical.
315.1 Wiring. Electrical connections, wiring and devices shall be installed in accordance with NFPA 70. Electrical equipment, appliances, and devices installed in areas that contain flammable vapors or dusts shall be of a type approved for such environment.

315.2 Controls. Required electrical, mechanical, safety, and operating controls shall be listed and labeled by a listing agency. Electrical controls shall be of such design and construction as to be suitable for installation in the environment in which they are located.

315.3 Solar Photovoltaic (PV) Systems. Solar photovoltaic systems shall be installed in accordance with Chapter 8.
   315.3.1 Fire Code. Solar photovoltaic systems shall comply with the requirements of the applicable fire code.
   315.3.2 Building Code. Solar photovoltaic systems shall comply with the requirements of the applicable building code.

316.0 Disposal of Liquid Waste.
316.1 General. It shall be unlawful for a person to cause, suffer, or permit the disposal of liquid wastes, heat transfer medium, or other liquids, in a place or manner, except through and by means of an approved drainage system installed and maintained in accordance with the provisions of this code. Waste that is deleterious to surface or subsurface waters shall not be discharged into the ground or into a waterway.

316.2 Connections to Drainage System Required. Receptors, drains, appurtenances, and appliances, used to receive or discharge liquid wastes, shall be connected to the drainage system of the building or premises in accordance with the requirements of this code.

316.3 Drainage. For heating or hot-water-supply boiler applications, the boiler room shall be equipped with a floor drain or other approved means for disposing of the accumulation of liquid wastes incident to cleaning, recharging, and routine maintenance. No steam pipe shall be directly connected to a part of a plumbing or drainage system, nor shall a water having a temperature above 140°F (60°C) be discharged under pressure directly into a part of a drainage system. Pipes from boilers shall discharge by means of indirect waste piping, as determined by the Authority Having Jurisdiction or the boiler manufacturer’s instructions.

316.4 Nonpotable Discharge. The discharge location for a relief device on a system utilizing other than potable water shall be in accordance with Section 316.1.

317.0 Hangers and Supports.
317.1 General. Piping, tubing, appliances, and appurtenances shall be supported in accordance with this code, the manufacturer’s installation instructions, and in accordance with the Authority Having Jurisdiction. Seismic restraints shall be in accordance with the building code.
317.2 Material. Hangers and anchors shall be of sufficient strength to support the weight of the pipe or tubing, and its contents. Piping shall be isolated from incompatible materials.

317.3 Suspended Piping. Suspended piping or tubing shall be supported at intervals not to exceed those shown in Table 317.3.

317.4 Alignment. Piping or tubing shall be supported in such a manner as to maintain its alignment and prevent sagging.

317.5 Underground Installation. Piping or tubing in the ground shall be laid on a firm bed for its entire length; where other support is otherwise provided, it shall be approved in accordance with Section 302.0.

---

### Table 317.3

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast</td>
<td>Lead and Oakum</td>
<td>5 feet, except 10 feet where 10 foot lengths are installed</td>
<td>Base and each floor, not to exceed 15 feet</td>
</tr>
<tr>
<td></td>
<td>Compression Gasket</td>
<td>Every other joint, unless over 4 feet then support each joint</td>
<td>Base and each floor, not to exceed 15 feet</td>
</tr>
<tr>
<td>Cast Iron Hubless</td>
<td>Shielded Coupling</td>
<td>Every other joint, unless over 4 feet then support each joint</td>
<td>Base and each floor, not to exceed 15 feet</td>
</tr>
<tr>
<td>Copper and Copper Alloys</td>
<td>Soldered, Brazed, Threaded, or Mechanical</td>
<td>1½ inches and smaller, 6 feet; 2 inches and larger, 10 feet</td>
<td>Each floor, not to exceed 10 feet</td>
</tr>
<tr>
<td>Steel Pipe for Water</td>
<td>Threaded or Welded</td>
<td>¾ inch and smaller, 10 feet; 1 inch and larger, 12 feet</td>
<td>Every other floor, not to exceed 25 feet</td>
</tr>
<tr>
<td>Schedule 40 PVC and ABS</td>
<td>Solvent Cemented</td>
<td>All sizes, 4 feet; allow for expansion every 30 feet</td>
<td>Base and each floor; provide mid-story guides; Provide for expansion every 30 feet</td>
</tr>
<tr>
<td>CPVC</td>
<td>Solvent Cemented</td>
<td>1 inch and smaller, 3 feet; 1¼ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>Steel</td>
<td>Mechanical</td>
<td>In accordance with standards acceptable to the Authority Having Jurisdiction</td>
<td></td>
</tr>
<tr>
<td>PE-RT</td>
<td>Insert and Compression</td>
<td>1 inch and smaller, 32 inches; 1¼ inches and larger, 4 feet</td>
<td>Base and each floor; provided mid-story guides</td>
</tr>
<tr>
<td>PE-RT in Support Channel</td>
<td>Cold Expansion Insert and Compression</td>
<td>¾ inch and smaller, 6 feet; 1 inch, 8 feet; 1¼ inches and larger, 10 feet</td>
<td>All sizes, 9 feet</td>
</tr>
<tr>
<td>PEX</td>
<td>Cold Expansion Insert and Compression</td>
<td>1 inch and smaller, 32 inches; 1¼ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>PEX in Support Channel</td>
<td>Cold Expansion Insert and Compression</td>
<td>¾ inch and smaller, 6 feet; 1 inch, 8 feet; 1¼ inches and larger, 10 feet</td>
<td>All sizes, 9 feet</td>
</tr>
<tr>
<td>PEX-AL-PEX</td>
<td>Metal Insert and Metal Compression</td>
<td>½ inch ¾ inch 1 inch</td>
<td>All sizes 98 inches</td>
</tr>
<tr>
<td>PE-AL-PE</td>
<td>Metal Insert and Metal Compression</td>
<td>½ inch ¾ inch 1 inch</td>
<td>All sizes 98 inches</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>Fusion weld (socket, butt,saddle, electrofusion), threaded (metal threads only), or mechanical</td>
<td>1 inch and smaller, 32 inches; 1¼ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

Notes:

1. Support adjacent to joint, not to exceed 18 inches (457 mm).
2. Brace not to exceed 40 foot (12 192 mm) intervals to prevent horizontal movement.
3. Support at each horizontal branch connection.
4. Hangers shall not be placed on the coupling.
5. Vertical water lines shall be permitted to be supported in accordance with recognized engineering principles with regard to expansion and contraction, where first approved by the Authority Having Jurisdiction.
317.6 **Hanger Rod Sizes.** Hanger rod sizes shall be not smaller than those shown in Table 317.6.

<table>
<thead>
<tr>
<th>TABLE 317.6 HANGER ROD SIZES</th>
<th>PIPE AND TUBE SIZE (inches)</th>
<th>ROD SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ – 4</td>
<td>¾</td>
<td></td>
</tr>
<tr>
<td>5 – 8</td>
<td>½</td>
<td></td>
</tr>
<tr>
<td>10 – 12</td>
<td>¾</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

317.7 **Strength.** Hangers and supports shall be of sufficient strength to withstand all static and dynamic loading conditions in accordance with its intended use. Pipe and tube hangers and supports with direct contact with piping or tubing shall be of approved materials that are compatible with the piping and will not cause galvanization.

318.0 **Protection of Piping, Materials, and Structures.**

318.1 **General.** Piping or tubing passing under or through walls shall be protected from breakage. Piping passing through or under cinders or other corrosive materials shall be protected from external corrosion in an approved manner. Approved provisions shall be made for expansion of hot liquid piping. Voids around piping or tubing passing through concrete floors on the ground shall be sealed.

318.2 **Installation.** Piping or tubing shall be installed so that piping, tubing, or connections will not subject to undue strains or stresses, and provisions shall be made for expansion, contraction, and structural settlement. No piping or tubing, unless designed and listed for such use, shall be directly embedded in concrete or masonry. No structural member shall be seriously weakened or impaired by cutting, notching, or otherwise, as defined in the building code.

318.3 **Fire-Resistant Construction.** Piping penetrations of fire-resistance-rated walls, partitions, floors, floor/ceiling assemblies, roof/ceiling assemblies, or shaft enclosures shall be protected in accordance with the requirements of the building code.

318.4 **Waterproofing of Openings.** Joints at the roof around pipes, ducts, or other appurtenances shall be made watertight by the use of lead, copper, galvanized iron, or other approved flashings or flashing material. Exterior wall openings shall be made watertight.

318.5 **Steel Nail Plates.** Plastic and copper or copper alloy piping penetrating framing members to within 1 inch (25.4 mm) of the exposed framing shall be protected by steel nail plates not less than No. 18 gauge (0.0478 inches) (1.2141 mm) in thickness. The steel nail plate shall extend along the framing member not less than 1½ inches (38 mm) beyond the outside diameter of the pipe or tubing.

318.6 **Sleeves.** Sleeves shall be provided to protect piping through concrete and masonry walls, and concrete floors.

**Exception:** Sleeves shall not be required where openings are drilled or bored.

318.8 **Structural Members.** A structural member weakened or impaired by cutting, notching, or otherwise shall be reinforced, repaired, or replaced so as to be left in a safe structural condition in accordance with the requirements of the building code.

319.0 **Protection of System Components.**

319.1 **Materials.** System components in contact with heat-transfer mediums shall be approved for such use. Components installed outdoors, shall be resistant to UV radiation.

319.2 **Corrosion.** Systems and components subject to corrosion shall be protected in an approved manner. Metal parts exposed to atmospheric conditions shall be of corrosion-resistant material.

319.3 **Mechanical Damage.** Portions of a system installed where subjected to mechanical damage shall be guarded against such damage by being installed behind protective barriers or, where located within a garage, be elevated or located out of the normal path of a vehicle, defined as a line perpendicular to the garage vehicle opening to the back wall extending 36 inches (914 mm) to either side along the back wall and to a height of 48 inches (1219 mm). Protective barriers for energy storage systems (ESS) shall be designed to resist, deflect, or visually deter vehicle impact in accordance with Section 319.3.1 through Section 319.3.3. (See Figure 319.3)

**Exception:** Where the clear height of the vehicle garage opening is equal to or less than 90 inches (2286 mm), ESS installed at least 36 inches (914 mm) above the finished floor shall not be subject to vehicle impact protection requirements.

319.3.1 **Bollards.** Where installed, construction of bollards shall be in accordance with one of the following:

1. 48 inches in length by 3 inches in diameter (1219 mm x 76 mm), Schedule 80 steel pipe embedded in a concrete pier 12 inches (305 mm) deep and 6 inches (152 mm) in diameter, with 36 inches (914 mm) of pipe exposed, filled with concrete, and spaced at intervals not exceeding 60 inches (1524 mm).
mm). Each bollard shall be located not less than 6 inches (152 mm) from an ESS.

(2) 36 inches in height by 3 inches in diameter (914 mm x 76 mm), Schedule 80 steel pipe fully welded to an 8 inch by 8 inch by ¼ inch (203 mm x 203 mm x 6.4 mm) thick steel plate and bolted to a concrete floor by means of four ½ inch (12.7 mm) concrete anchors with not less than 3 inches (76 mm) of embedment. Spacing shall not exceed 60 inches (1524 mm), and each bollard shall be located not less than 6 inches (152 mm) from the ESS.

(3) Pre-manufactured steel pipe bollards shall be filled with concrete and anchored in accordance with the manufacturer's installation instructions. Spacing between bollards shall not exceed 60 inches (1524 mm). Each bollard shall be located not less than 6 inches (152 mm) from the ESS.

319.3.2 Wheel Barriers. Where installed, construction of wheel barriers shall be in accordance with one of the following:

(1) 6 inches in height by 6 inches in width (152 mm x 152 mm), wheel stop made of concrete or polymer, anchored to the concrete floor at intervals of not less than 36 inches (914 mm) and located not less than 54 inches (1372 mm) from the ESS. Not less than two ½ inch (12.7 mm) diameter concrete anchors with 3 inches (76 mm) of embedment per wheel stop shall be used. Spacing between wheel stops shall not exceed 36 inches (914 mm).

(2) Pre-manufactured wheel stops shall be anchored in accordance with the manufacturer's installation instructions.

319.3.3 Other Approved Methods. Protective barriers installed 24 inches (610 mm) above grade and designed to resist a 2000 pound-force (8896 N) impact in the direction of vehicle travel shall be permitted.

320.0 Trenching, Excavation, and Backfill.

320.4 Excavations. Excavations shall be completely backfilled as soon after inspection as practicable. Precaution shall be taken to ensure compactness of backfill around piping without damage to such piping. Trenches shall be backfilled in thin layers to 12 inches (305 mm) above the top of the piping with clean earth, which shall not contain stones, boulders, cinder fill, frozen earth, construction debris, or other materials that will damage or break the piping or cause corrosive action. Mechanical devices such as bulldozers, graders, etc., shall be permitted to then be used to complete backfill to grade. Fill shall be properly compacted. Precautions shall be taken to ensure permanent stability for pipe laid in filled or made ground.

321.0 Abandonment.

321.1 General. An abandoned system or part thereof shall be disconnected from remaining systems, drained, plugged, and capped in an approved manner.

321.2 Storage Tank. An underground water storage tank that has been abandoned or discontinued otherwise from use shall be completely drained and filled with earth, sand, gravel, concrete, or other approved material or removed in a manner satisfactory to the Authority Having Jurisdiction.

322.0 Other Systems.

322.1 General. Other systems installed in conjunction with solar energy, hydronic, or geothermal systems for the purpose of domestic hot water, comfort cooling or heating, swimming pools, spas, or other similar facilities, shall comply with the applicable codes.

322.2 Duct Systems. Ducts and plenums that are portions of a heating, cooling, absorption or evaporative cooling, or exhaust system shall comply with the requirements of the Mechanical Code.
FIGURE 319.3
PROTECTIVE BARRIERS FOR ESS

For SI units: 1 inch = 25.4 mm
CHAPTER 4
HYDRONICS

401.0 General.
401.1 Applicability. This chapter shall apply to hydronic piping systems that are part of heating, cooling, ventilation, refrigeration, and air conditioning systems. Such piping systems include steam, hot water, radiant heating and cooling, chilled water, steam condensate, condenser water, solar thermal systems, ground source heat pump systems, snow and ice melt systems, ambient temperature loops (ATL), and district thermal energy loops. The regulations of this chapter shall govern the construction, location, and installation of hydronic piping systems. (See Appendix E for recommended configurations of both residential and non-residential closed-loop hydronic heating and cooling systems.)

401.2 Insulation. Surfaces within reach of building occupants shall not exceed 140°F (60°C). Where sleeves are installed, the insulation shall continue full size through them.

Coverings and insulation used for piping shall be of material approved for the operating temperature of the system and the installation environment. Where installed in a plenum, the insulation, jackets, and lap-seal adhesives, including pipe coverings and linings, shall have a flame-spread index not to exceed 25 and a smoke-developed index not to exceed 50 where tested in accordance with ASTM E84 or UL 723.

401.3 Water Hammer Protection. The 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.

401.5 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.

401.6 Heat Transfer Fluid Quality. Heat transfer fluids used in closed-loop hydronic systems shall be in accordance with IAPMO/ANSI H1001.1.

401.6.1 Ethylene Glycol. Ethylene glycol shall not be used in one- and two-unit residential systems. In existing systems, where ethylene glycol is used, there shall be no direct or permanent potable water connections. Where a temporary potable water connection is required, a backflow preventer shall be installed.

401.7 Disposal of Hydronic Fluid. Hydronic system fluids that contain additives such as antifreeze, corrosion inhibitors, and cleaning solutions shall be recycled or disposed of in an approved manner in accordance with the Authority Having Jurisdiction.

401.8 Heat Emitters. Heat emitters shall be installed in accordance with the manufacturer’s installation instructions.

401.9 Mechanical Devices. Where listed mechanical devices are used, the manufacturer’s installation instructions as to the location and method of installation shall be followed.

401.10 Flexible Connectors. Listed flexible connectors shall be installed in readily accessible locations.

401.11 Freeze Protection. Hydronic systems and components shall be designed, installed, and protected from freezing. Where glycol is used for freeze protection, the percent of glycol by volume shall be determined based on the freezing point of the solution and type of mixture in accordance with Table 401.11, or the manufacturer’s specifications.

401.11.1 Antifreeze Requirements. Antifreeze shall be added to a closed hydronic system where one or more of the following conditions exist:

1. System component(s) are exposed to freezing conditions during normal operation.
2. The hydronic system serves as a snow and ice melt system in accordance with Section 417.0, or
3. Where required by the equipment manufacturer.

Exception: Antifreeze shall not be required where a system is continuously monitored or specifically designed not to require antifreeze, and is not subject to freezing as a result of either of the following:

1. Loss of electrical power,
2. Loss of a fuel source.

<table>
<thead>
<tr>
<th>PERCENT GLYCOL BY VOLUME (% v/v)</th>
<th>FREEZING POINT, °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETHYLENE GLYCOL*</td>
<td>PROPYLENE GLYCOL</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>40</td>
<td>-12</td>
</tr>
<tr>
<td>50</td>
<td>-35</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8

* Ethylene glycol shall not be used in one- and two-unit residential systems. In existing systems where ethylene glycol is used, there shall be no direct or permanent potable water connections. Where a temporary potable water connection is required, a backflow preventer shall be installed.

402.0 Protection of Potable Water Supply.
402.1 Prohibited Sources Connections. Hydronic systems or parts thereof, shall be constructed in such a manner that polluted, contaminated water, or substances shall not enter hydronic system fluid does not enter a portion of the potable water distribution system from being separately delivered to any potable water fixture or point of 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 Chemical Injection. Additives or chemicals shall be compatible with system components. Where systems include an additive, chemical injection or provisions for such injection, the potable water supply shall be protected by an air gap in accordance with ASME A112.1.2, an air gap fitting listed and labeled in accordance with ASME A112.1.3, or a reduced-pressure principle backflow prevention assembly listed and labeled in accordance with ASSE 1013.

402.3 Protection of Potable Water. Where a hydronic system makeup fluid supply is connected to a potable water system, the potable water system shall be protected from backflow from the hydronic system in accordance with the Uniform Plumbing Code.

402.4 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.

402.5 Dual Purpose Water Heaters. Dual purpose water heaters shall be configured to maintain fluid separation between the potable water and the hydronic system fluid. Where an integral heat exchanger is installed in a dual purpose water heater, the installation shall comply with the requirements for a single-wall heat exchanger in Section 313.1. Scald protection shall be provided on the potable water circuit in compliance with ASSE 1070/ASME A112.1070/CSA B125.70, point of generation requirements.

403.0 Capacity of Heat Source.

403.1 Heat Source. The heat source shall be sized to the design load.

403.2 Dual Purpose Water Heaters. Water heaters utilized for combined space-heating and water-heating applications shall comply 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 water requirements and the space heating design requirements corrected for hot water first-hour draw recovery.

<table>
<thead>
<tr>
<th>TABLE 403.2 WATER HEATERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE</strong></td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>Gas-Fired, 75,000 Btu/h or less, Storage</td>
</tr>
<tr>
<td>Gas-Fired, Above 75,000 Btu/h Storage, Circulating and Instantaneous</td>
</tr>
<tr>
<td>Electric, Space Heating</td>
</tr>
<tr>
<td>Solid Fuel-Fired</td>
</tr>
</tbody>
</table>

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

403.3 Tankless Water Heater. Tankless water heaters used in 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.

403.4 Potable Water as a Hydronic Fluid. Potable water shall not be used as a hydronic fluid in an open-loop heating system unless all of the following conditions are met:

1. A maximum of one system loop using potable water as the hydronic fluid is allowed per heat source;
2. The total length of piping of the heating system containing potable water does not exceed 50 feet (15 240 mm);
3. The total volume of potable water in the heating system loop, including the volume within the heat distribution unit(s), heat exchanger, or radiant surface, does not exceed 13 gallons (49 L); and
4. The normal operating supply temperature of the potable water to the heat distribution unit(s), heat exchanger, or radiant surface is not less than 140°F (60°C).

404.0 Identification of Piping Potable and Non-potable Water Piping Systems.

404.1 General. In buildings where potable water and non-potable water systems are installed, each system shall be clearly identified in accordance with Section 404.2 through Section 404.7.

404.2 Color and Information. Each system shall be identified with a colored pipe or band and coded with paints, wraps, and materials compatible with the piping.

404.3 Potable Water. Potable water systems shall be identified with a green background with white lettering. The minimum size of the letters and length of the color field shall be in accordance with Table 404.3.

<table>
<thead>
<tr>
<th>TABLE 404.3 MINIMUM LENGTH OF COLOR FIELD AND SIZE OF LETTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OUTSIDE DIAMETER OF PIPE OR COVERING</strong></td>
</tr>
<tr>
<td>(inches)</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>½ to 1¼</td>
</tr>
<tr>
<td>1½ to 2</td>
</tr>
<tr>
<td>2½ to 6</td>
</tr>
<tr>
<td>8 to 10</td>
</tr>
<tr>
<td>Over 10</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

404.4 Nonpotable Water. Nonpotable water systems shall have a yellow background with black uppercase lettering, with words “CAUTION: NONPOTABLE WATER. DO NOT DRINK.” Each nonpotable system shall be identified to des-
ignite the liquid being conveyed, and the direction of normal flow shall be clearly shown. The minimum size of the letters and length of the color field shall comply with Table 404.3.

**404.5 Location of Piping Identification.** The background color and required information shall be indicated every 20 feet (6096 mm) but not less than once per room, and shall be visible from the floor level.

**404.6 Flow Directions.** Flow directions shall be indicated on the system.

**404.7 Identification of Chemical Additives.** In systems where chemical additives are used, documentation including the following information shall be readily accessible and maintained onsite:

1. **Concentrations**
2. **Maintenance requirements**
3. **Maintenance log**
4. **Safety data sheet (SDS)**

**405.0 Installation, Testing, and Inspection.**

**405.1 Operating Instructions.** Operating and maintenance information shall be provided to the building owner.

**405.2 Pressure Testing.** System piping and components shall be tested with a pressure of not less than one and one-half times the operating pressure but not less than 100 psi (689 kPa). Piping shall be tested with water or air except that plastic pipe shall not be tested with air. Test pressures shall be held for a period of not less than 30 minutes with no perceptible drop in pressure. These tests shall be made in the presence of the Authority Having Jurisdiction.

**Exceptions:**

1. For PEX, PP-R, PP-RCT, PEX-AL-PEX, PE-RT, and PE-AL-PE piping systems, testing with air shall be permitted where authorized by the manufacturer’s instructions for the PEX, PP-R, PP-RCT, PEX-AL-PEX, PE-RT, and PE-AL-PE pipe and fittings products, and air testing is not prohibited by applicable codes, laws, or regulations outside this code.
2. Copper tubing shall be tested at not less than 80 psi (552 kPa).

**405.3 Flushing.** Heating and cooling sources, system piping and tubing shall be flushed after installation with water or a cleaning solution. Cleaning and flushing of the heating and cooling sources shall comply with the manufacturer’s instructions. The cleaning solution shall be compatible with all system components and shall be used in accordance with the manufacturer’s instructions.

**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.

**407.0 Heating Appliances and Equipment.**

**407.1 General.** Heating appliances, equipment, safety and operational controls shall be listed for their intended use in a hydronic heating system and installed in accordance with the manufacturer’s installation instructions.

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

1. **Condensing Boilers.** A condensing boiler, in which the heat exchanger and venting system are designed to operate with condensing flue gases, shall be permitted to be connected directly to the panel heating system without a protective mixing device.
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 401.5.

**407.3 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 402.0.

**407.3.1 Temperature Limitations.** Where a combined space- and water-heating application requires water for space heating at temperatures exceeding 140°F (60°C), a thermostatic mixing valve in accordance with ASSE 1017 shall be installed to temper the water supplied to the potable water distribution system to a temperature of 140°F (60°C) or less.

**407.4 Solar Heat Collector Systems.** Solar water heating systems used in hydronic panel radiant heating systems shall be installed in accordance with Chapter 5.

**407.5 Heat Pumps.** Heat pumps shall comply with UL 1995 or UL 60335-2-40. Air-source heat pumps shall also comply with AHRI 210/240. In addition, ground-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. Heat pumps shall be fitted with a means to indicate that the compressor is locked out.

**408.0 Expansion Tanks.**

**408.1 General.** An expansion tank shall be installed in each hydronic closed-loop system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed type, incorporating a diaphragm or bladder to
ensure the isolation of the system fluid from the pre-charge gas or from the atmosphere. Plain compression tanks shall not be permitted. Expansion tanks shall be rated for the pressure of the system. [See Figure 408.1(1) for an example of a simplified schematic of a closed-loop system incorporating a diaphragm type expansion tank.]

Exceptions:

1. Drainback type solar thermal systems shall not require a hydronic expansion tank.
2. An engineered fluid expansion storage system shall be permitted to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]

408.2 Installation. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions. Each expansion tank shall be equipped with a shutoff device that will remain open during operation of the hydronic system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off. Provisions shall be made for draining the tank without emptying the system. Expansion tanks shall be securely fastened to or supported by the structure. Supports shall be capable of carrying twice the weight of the tank filled with water without placing a strain on connecting piping. Hot-water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

408.3 Closed-Type Expansion Tanks. Closed-type expansion tanks shall be designed for a hydrostatic test pressure of two and one-half times the allowable working pressure of the system. Expansion tanks for systems designed to operate at more than 30 pounds-force per square inch (psi) (207 kPa) shall comply with ASME BPVC Section VIII.1.

408.4 Sizing. Expansion tanks shall be sized to accept the design expansion volume of the fluid in the system. The minimum capacity of a closed-type expansion tank shall be sized in accordance with Section 605.3.

409.0 Materials.

409.1 Pipe, Tubing, and Fittings. Hydronic pipe and tubing shall comply with the applicable standards referenced in Table 409.1 and shall be approved for use based on the intended purpose. Materials shall be rated for the operating temperature and pressure of the system and shall be compat-
### Table 409.1
**Materials for Hydronic and Solar Thermal System, Piping, Tubing, and Fittings**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>PIPO/TUBING</th>
<th>FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray Iron</td>
<td>—</td>
<td>ASTM A126</td>
</tr>
<tr>
<td>Malleable Iron</td>
<td>—</td>
<td>ASME B16.3</td>
</tr>
<tr>
<td>Chlorinated Polyvinyl Chloride (CPVC)</td>
<td>ASTM D2846, ASTM F441, ASTM F432, CSA B137.6</td>
<td>ASSE 1061, ASTM D2846, ASTM F437, ASTM F438, ASTM F439, ASTM F1970, CSA B137.6</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2165, ASTM F2389, CSA B137.11, NSF/ANSI 358-2</td>
<td>ASTM F2165, ASTM F2389, CSA B137.11, NSF/ANSI 358-2</td>
</tr>
<tr>
<td>Polyethylene of Raised Temperature (PE-RT)</td>
<td>ASTM F2165, ASTM F2623, ASTM F2769, CSA B137.18</td>
<td>ASTM D2464, ASTM F1970, CSA B137.10</td>
</tr>
<tr>
<td>Polyethylene/Aluminum/Polyethylene (PE-AL-PE)</td>
<td>ASTM F1282, ASTM F2165, CSA B137.9</td>
<td>ASTM F1282, ASTM F1974, ASTM F2165, CSA B137.9</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>ASTM A269, ASTM A312, ASTM A554, ASTM A778</td>
<td>ASTM F1476, ASTM F1548, ASTM F3226, IAPMO IGC 353, IAPMO/ANSI/CAN Z1117</td>
</tr>
<tr>
<td>Chlorinated Polyvinyl Chloride/Aluminum/ Chlororinated Polyvinyl Chloride (CPVC/AL/CPVC)</td>
<td>ASTM F2855</td>
<td>ASTM D2846</td>
</tr>
</tbody>
</table>

**Notes:**

1. Ductile and gray iron.
2. Only Type K, L, or M shall be permitted to be installed.
ible with the type of heat transfer fluid. Pipe fittings and valves shall be approved for the specific installation with the piping, materials to be installed and shall comply with the applicable standards referenced in Table 409.1. Where required, exterior piping shall be protected against freezing, UV radiation, corrosion and degradation. Embedded pipe or tubing shall comply with Section 418.2.

**409.2 Expansion and Contraction.** Pipe and tubing shall be so installed that it will not be subject to undue strains or stresses, and provisions shall be made for expansion, contraction, and structural settlement.

**409.3 Hangers and Supports.** Pipe and tubing shall be supported in accordance with Section 317.0 and Table 317.3. Equipment that is part of the piping system shall be provided with additional support in accordance with this code and manufacturer’s installation instructions. Radiant systems utilizing heat emission or transfer plates shall have a gap of at least ¼ inch (6.4 mm) between adjacent plates or in accordance with the manufacturer’s installation instructions.

**409.4 Oxygen Diffusion Corrosion.** PEX and PE-RT tubing in closed hydronic systems shall contain an oxygen barrier.

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

**409.4.1 Vented Atmospheric Closed-Loop Systems.** All components installed in a vented closed-loop system shall be constructed of non-ferrous or other corrosion resistant materials. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]

**409.4.2 Non-Oxygen Barrier Closed-Loop Systems.** All components installed in a non-oxygen barrier system shall be constructed of non-ferrous or other corrosion resistant materials.

**410.0 Joints and Connections.**

**410.1 General.** Joints and connections shall be of an approved type. Joints shall be gas and watertight and designed for the pressure of the hydronic system. Changes in direction shall be made by the use of fittings or with pipe bends. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions. Joints used underground shall be of an approved type for buried applications.

**410.2 Pipe Bends.** Pipe bends shall be formed in accordance with Section 410.2.1 through Section 410.2.3.

**410.2.1 Crosslinked Polyethylene (PEX) Tubing.** Crosslinked polyethylene (PEX) tubing bends shall have a bend radius of not less than eight times the outside diameter (OD) of the tubing or shall be in accordance with the manufacturer’s installation instructions.

**410.2.2 Polyethylene (PE) Plastic Pipe/Tubing.** Polyethylene pipe and tubing bends shall have a bend radius in accordance with Table 410.2.2. When a fitting or flange connection is present in the pipe bend, the minimum bend radius shall be one hundred times the pipe outside diameter (OD) for a distance of five times the pipe diameter on either side of the fitting location.

**Table 410.2.2**

<table>
<thead>
<tr>
<th>DIMENSION RATIO (DR)</th>
<th>MINIMUM COLD BEND RADIUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>20 x Pipe OD</td>
</tr>
<tr>
<td>7.3</td>
<td>20 x Pipe OD</td>
</tr>
<tr>
<td>9</td>
<td>25 x Pipe OD</td>
</tr>
<tr>
<td>11</td>
<td>25 x Pipe OD</td>
</tr>
<tr>
<td>13.5</td>
<td>27 x Pipe OD</td>
</tr>
<tr>
<td>17</td>
<td>27 x Pipe OD</td>
</tr>
<tr>
<td>21</td>
<td>34 x Pipe OD</td>
</tr>
<tr>
<td>26</td>
<td>42 x Pipe OD</td>
</tr>
<tr>
<td>32.5</td>
<td>52 x Pipe OD</td>
</tr>
<tr>
<td>41</td>
<td>100 x Pipe OD</td>
</tr>
</tbody>
</table>

**410.2.3 Polyethylene of Raised Temperature (PE-RT) Tubing.** Polyethylene of raised temperature (PE-RT) tubing bends shall have a bend radius of not less than eight times the outside diameter (OD) of the tubing or shall be in accordance with the manufacturer’s installation instructions.

**410.3 Chlorinated Polyvinyl Chloride (CPVC) Pipe.** Joints between chlorinated polyvinyl chloride (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. Removable and nonremovable push fit fittings with an elastomeric o-ring that employ quick assembly push fit connectors shall be in accordance with ASSE 1061.

2. Solvent cement joints for 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, green, or red in color, shall be permitted for pipe and fittings manufactured in accordance with ASTM D2846, ½ of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, ½ of an 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.

3. Threaded joints for CPVC pipe shall be made with pipe threads in accordance with ASME B1.20.1. A minimum of
Schedule 80 shall be permitted to be threaded and the pressure rating shall be reduced by 50 percent. The use of molded fittings shall not result in a 50 percent reduction in the pressure rating of the pipe provided that the molded fittings shall be fabricated so that the wall thickness of the material is maintained at the threads. Thread sealant compound that is compatible with the pipe and fitting, insoluble in water, and nontoxic shall be applied to male threads. Caution shall be used during assembly to prevent over tightening of the CPVC components once the thread sealant has been applied. Female CPVC threaded fittings shall be used with plastic male threads only.

**410.4 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.

3. Pressed fittings for copper or copper alloy pipe or tubing shall have an elastomeric o-ring that forms the joint. Joints shall have been cleaned bright by manual or mechanical means. Flux shall be applied to joint surfaces where required by manufacturer’s recommendation. Brazing filler metal in accordance with AWS A5.8 shall be applied at the point where the pipe or tubing enters the socket of the fitting.

4. Flared joints for soft copper or copper alloy tubing shall be made with fittings that are in accordance with the applicable standards referenced in Table 409.1. Pipe or tubing shall be cut square using an appropriate tubing cutter. The tubing shall be reamed to full inside diameter, resized to round, and expanded with a proper flaring tool.

5. Mechanically formed tee fittings shall have extracted collars that shall be formed in a continuous operation consisting of drilling a pilot hole and drawing out the pipe or tube surface to form a collar having a height not less than three times the thickness of the branch tube wall. The branch pipe or tube shall be notched to conform to the inner curve of the run pipe or tube and shall have two dimple depth stops to ensure that penetration of the branch pipe or tube into the collar is of a depth for brazing and that the branch pipe or tube does not obstruct the flow in the main line pipe or tube. Dimple depth stops shall be in line with the run of the pipe or tube. The second dimple shall be 1/3 of an inch (6.4 mm) above the first and shall serve as a visual point of inspection. Fittings and joints shall be made by brazing. Soldered joints shall not be permitted.

6. Pressed fittings for copper or copper alloy tubing or pipe that employ quick assembly push fit connectors shall be in accordance with ASSE 1061. Push fit fittings for copper or copper alloy pipe or tubing shall have an approved elastomeric o-ring that forms the joint. Joints shall be clean from dirt and moisture. Solvent cements in accordance with ASTM F656 shall be applied to the joint surfaces until capillary action draws the molten solder into the molten metal, ensuring a uniform capillary space around the joint. Solder shall not become noncorrosive and nontoxic after soldering. Insert the tubing and fittings shall be fabricated so that the wall thickness of the material is maintained at the threads. Thread sealant compound that is compatible with the pipe and fitting, insoluble in water, and nontoxic shall be applied to the joint surfaces and joints shall be made by brazing. Soldered joints shall not be permitted.

7. Threaded joints for copper or copper alloy pipe shall be made with pipe threads in accordance with ASME B1.20.1. Thread sealant tape or compound shall be applied only on male threads, and such material shall be of approved types, insoluble in water, and nontoxic.
410.6 Cross-Linked Polyethylene (PEX) Pipe. Joints between cross-linked polyethylene (PEX) pipe and fittings shall be installed with fittings for PEX tubing that comply with the applicable standards referenced in Table 409.1. PEX tubing labeled in accordance with ASTM F876 or ASTM F3253 shall be marked with the applicable standard designation for the fittings specified for use with the tubing. Mechanical joints shall be installed in accordance with the manufacturer’s installation instructions.

410.7 Cross-Linked Polyethylene/Aluminum/ Cross-Linked Polyethylene (PEX-AL-PEX) Pipe. Joints between cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe and fittings shall be installed in accordance with one of the following methods:

1) Mechanical joints between PEX-AL-PEX pipe and fittings shall include mechanical and compression type fittings and insert fittings with a crimping ring. Insert fittings utilizing a crimping ring shall be in accordance with ASTM F1974 or ASTM F2434. Crimp joints for crimp insert fittings shall be joined to PEX-AL-PEX pipe by the compression of a crimp ring around the outer circumference of the pipe, forcing the pipe material into annular spaces formed by ribs on the fitting.

2) Compression joints shall include compression insert fittings and shall be joined to PEX-AL-PEX pipe through the compression of a split ring or compression nut around the outer circumference of the pipe, forcing the pipe material into the annular space formed by the ribs on the fitting.

410.8 Ductile Iron Pipe. Joints between ductile iron pipe and fittings shall be installed in accordance with one of the following methods:

1) Mechanical joints for ductile iron pipe and fittings shall consist of a bell that is cast integrally with the pipe or fitting and provided with an exterior flange having bolt holes and a socket with annular recesses for the sealing gland and the plain end of the pipe or fitting. The elastomeric gland shall comply with AWWA C111/A21.11. Lubricant recommended for the application by the pipe manufacturer shall be applied to the gland and plain end of the pipe.

2) Push-on joints for ductile iron pipe and fittings shall consist of a single elastomeric gasket that shall be assembled by positioning the elastomeric gasket in an annular recess in the pipe or fitting socket and forcing the plain end of the pipe or fitting into the socket. The plain end shall compress the elastomeric gasket to form a positive seal and shall be designed so that the elastomeric gasket shall be locked in place against displacement. The elastomeric gasket shall comply with AWWA C111/A21.11. Lubricant recommended for the application by the pipe manufacturer shall be applied to the gland and plain end of the pipe.

410.9 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe or tubing and fittings shall be installed in accordance with one of the following methods:

1) Butt-fusion joints shall be installed in accordance with ASTM F2620 and shall be made 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) Electro-fusion joints shall be heated 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.

3) Socket-fusion joints shall be installed in accordance with ASTM F2620 and shall be made 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.

4) Mechanical joints between PE pipe or tubing and fittings shall include insert and mechanical compression fittings that provide a pressure seal resistance to pullout. Joints for insert fittings shall be made by cutting the pipe square, using a cutter designed for plastic piping, and removal of sharp edges. Two stainless steel clamps shall be placed over the end of the pipe. Fittings shall be checked for proper size based on the diameter of the pipe. The end of pipe shall be placed over the barbed insert fitting, making contact with the fitting shoulder. Clamps shall be positioned equal to 180 degrees (3.14 rad) apart and shall be tightened to provide a leak tight joint. Compression type couplings and fittings shall be permitted for use in joining PE piping and tubing. Stiffeners that extend beyond the clamp or nut shall be prohibited. Bends shall be not less than 30 pipe diameters, or the coil radius where bending with the coil. Bends shall not be permitted closer than 10 pipe diameters of a fitting or valve. Mechanical joints shall be designed for their intended use.

410.10 Polyethylene/Aluminum/Polyethylene (PE-ALPE). Joints between polyethylene/aluminum/polyethylene (PE-AL-PE) pipe and fittings shall be installed in accordance with one of the following methods:

1) Mechanical joints for PE-AL-PE pipe or tubing and fittings shall be either of the metal insert fittings with a split ring and compression nut or metal insert fittings with copper crimp rings. Metal insert fittings shall comply with ASTM F1974. Crimp insert fittings shall be joined to the pipe by placing the copper crimp ring around the outer circumference of the pipe, forcing the pipe material into the space formed by the ribs on the fitting until the pipe contacts the shoulder of the fitting. The crimp ring shall then be positioned on the pipe so the edge of the crimp ring is ⅛ of an inch (3.2 mm) to ¼ of an inch (6.4 mm) from the end of the pipe. The jaws of the crimping tool shall be centered over the crimp ring and tool perpendicular to the barb. The jaws shall be closed around the crimp ring and shall not be crimped more than once.
(2) Compression joints for PE-AL-PE pipe or tubing and fittings shall be joined through the compression of a split ring, by a compression nut around the circumference of the pipe. The compression nut and split ring shall be placed around the pipe. The ribbed end of the fitting shall be inserted onto the pipe until the pipe contacts the shoulder of the fitting. Position and compress the split ring by tightening the compression nut onto the insert fitting.

410.11 Polyethylene of Raised Temperature (PE-RT). Joints between polyethylene of raised temperature (PE-RT) tubing and fittings shall comply be installed in accordance with the manufacturer’s installation instructions and shall comply with the standards listed in Table 409.1. Metal insert fittings, metal compression fittings, and plastic fittings shall be manufactured to and marked in accordance with the standards for fittings in Table 409.1.

410.12 Polypropylene (PP) Pipe. Joints between polypropylene pipe and fittings shall be installed in accordance with one of the following methods:

(1) Heat-fusion joints for polypropylene (PP) pipe shall be installed with socket-type heat-fused polypropylene fittings, butt-fusion polypropylene fittings or pipe, or electro-fusion polypropylene fittings. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F2389 or CSA B137.11.

(2) Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions. Polypropylene pipe shall not be threaded. Polypropylene transition fittings for connection to other piping materials shall only be threaded by use of copper alloy or stainless steel inserts molded in the fitting.

410.13 Polyvinyl Chloride (PVC) Pipe. Joints between polyvinyl chloride pipe and fittings shall be installed in accordance with one of the following methods:

(1) Mechanical joints shall be designed to provide a permanent seal and shall be of the mechanical or push-on joint. The mechanical joint shall include a pipe spigot that has a wall thickness to withstand without deformation or collapse; the compressive force exerted where the fitting is tightened. The push-on joint shall have a minimum wall thickness of the bell at any point between the ring and the pipe barrel. The elastomeric gasket shall comply with ASTM D3139, and be of such size and shape as to provide a compressive force against the spigot and socket after assembly to provide a positive seal.

(2) Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Pipe shall be cut square and pipe shall be deburred. Where surfaces to be joined are cleaned and free of dirt, moisture, oil, and other foreign material, apply primer purple in color in accordance with ASTM F656. Primer shall be applied until the surface of the pipe and fitting is softened. Solvent cements in accordance with ASTM D2564 shall be applied to all joint surfaces. Joints shall be made while both the inside socket surface and outside surface of pipe are wet with solvent cement. Hold joint in place and undisturbed for 1 minute after assembly.

(3) Threads shall comply with ASME B1.20.1. A minimum of Schedule 80 shall be permitted to be threaded; however, the pressure rating shall be reduced by 50 percent. The use of molded fittings shall not result in a 50 percent reduction in the pressure rating of the pipe. Female PVC threaded fittings shall be used with plastic male threads only.

410.14 Steel Pipe and Tubing. Joints between steel pipe or tubing and fittings shall be installed in accordance with one of the following methods:

(1) Mechanical joints shall be made with an approved and listed elastomeric gasket.

(2) Threaded joints shall be made with pipe threads that are in accordance with ASME B1.20.1. Thread sealant tape or compound shall be applied only on male threads, and such material shall be of approved types, insoluble in water, and nontoxic.

(3) Welded joints shall be made by electrical arc or oxygen/acetylene method. Joint surfaces shall be cleaned by an approved procedure. Joints shall be welded by an approved filler metal.

(4) Pressed joints shall have an elastomeric o-ring that forms the connection. The pipe or tubing shall be fully inserted into the fitting, and the pipe or tubing marked at the shoulder of the fittings. Pipe or tubing shall be cut square, chamfered, and reamed to full inside diameter. The fitting alignment shall be checked against the mark on the pipe or tubing to ensure the pipe or tubing is fully inserted into the fitting. The joint shall be pressed using the tool recommended by the manufacturer.

410.15 Stainless Steel Pipe and Joints. Joining methods for stainless steel pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 410.15.1 or Section 410.15.2.

410.15.1 Mechanical Joints. Mechanical joints shall be designed for their intended use. Such joints shall include compression, flanged, grooved, press-connect, and threaded.

410.15.2 Welded Joints. Welded joints shall be either fusion or resistance welded based on the selection of the base material. The chemical composition of the filler metal shall comply with AWS A5.9 based on the alloy content of the piping material.

410.16 Joints Between Different Materials. Joints between different types of materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 410.16.1 and Section 410.16.2.

410.16.1 Copper or Copper Alloy Pipe or Tubing to Threaded Pipe Joints. Joints from copper or copper alloy pipe or tubing to threaded pipe of a material
other than copper or copper alloy shall be made by the use of copper alloy adapter, copper alloy nipple [minimum 6 inches (152 mm)], dielectric fitting, or dielectric union in accordance with ASSE 1079. The joint between the copper or copper alloy pipe or tubing and the fitting shall be a soldered, brazed, flared, or pressed joint and the connection between the threaded pipe and the fitting shall be made with a standard pipe size threaded joint.

410.16.2 Plastic Pipe to Other Materials. Where connecting plastic pipe to other types of plastic or other types of piping materials, approved adapter or transition fittings designed and listed for the specific transition intended shall be used. Except as provided in the plumbing code, PVC pipe and fittings shall not be solvent welded to any other unlike material.

410.16.2.1 Transition Joint. For non-pressurized systems rated at 25 psi (172 kPa) or less, a solvent cement transition joint between ABS and PVC drainpipe and fittings shall be made using listed transition solvent cement in accordance with ASTM D3138. PVC and ABS pipe and fittings shall not be solvent welded to any other unlike material.

411.0 System Controls.

411.1 Water Temperature Controls. A heat source or system of commonly connected heat sources shall be protected by a water-temperature-activated operating control to stop heat output of the heat source where the system water reaches a pre-set operating temperature.

411.2 Operating Steam Controls. A steam heat source or system of commonly connected steam heat sources shall be protected by a pressure-activated control to shut off the fuel supply where the system pressure reaches a pre-set operating pressure.

411.2.1 Water-Level Controls. A primary water-level control shall be installed on a steam heat source to control the water level in the heat source. The control shall be installed in accordance with the manufacturer’s installation instructions.

411.3 Occupied Spaces. A temperature-sensing device shall be installed in the occupied space to regulate the operation of the hydronic system.

411.4 Simultaneous Operation. Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling.

411.5 Temperature Reading. A temperature gauge or transmitter shall be installed for reading the fluid temperatures in the panel system supply and heat source outlet. One temperature gauge or transmitter shall be permitted where the temperature between the heat source outlet and panel system supply are the same.

412.0 Pressure and Flow Controls.

412.1 Balancing. A means for balancing distribution loops, heat emitting devices, and multiple-boiler installations shall be provided in accordance with the manufacturer’s instructions. A means for balancing and flow control shall include the piping design, pumping equipment, or balancing devices.

412.2 Low-Water Control. Direct-fired heat sources within a closed heating system shall have a low-water fuel cut-off device, except as specified in Section 412.3. Where a low-water control is integral with the heat source as part of the appliance’s integrated control, and is listed for such use, a separate low-water control shall not be required. An external cut-off device shall be installed in accordance with the heat-source manufacturer’s installation instructions. No valve shall be located between the external low-water fuel cut-off and the heat-source unit. Where a pumped condensate return is installed, a second low-water cut-off shall be provided.

412.3 Flow-Sensing Devices. A direct-fired heat source, requiring forced circulation to prevent overheating, shall have a flow-sensing device installed with the appliance or such device shall be integral with the appliance. A low-water fuel cut-off device shall not be required.

412.4 Automatic Makeup Fluid. Automatic makeup fluid shall be in accordance with Section 412.4.1 for potable water makeup fluid or Section 412.4.2 for nonpotable makeup fluid.

412.4.1 Potable Makeup Fluid. Where as potable water 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 potable water supply shall be located at the expansion tank connection or other approved location. Where the hydronic fluid contains a chemical additive, a potable water supply shall be protected in accordance with Section 402.0.

On systems using only water as a heat transfer medium, and where pressurization is achieved using a potable water supply, a pressure-reducing valve shall be installed on a potable water makeup 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.

412.4.2 Nonpotable Makeup Fluid. Makeup fluid systems that are designed to add pre-mixed antifreeze solutions shall be permitted. Such systems shall include, but not be limited to, glycol feeders and limited-volume reservoir systems.

On systems using additives, such as glycol or corrosion inhibitors, the use of a system pressurization unit or glycol feeder shall be required. The fluid capacity of the tank or reservoir shall not exceed the greater of 5 gallons (19 L), or 5 percent of the total system fluid volume.

412.5 Differential Pressure Regulation. Provisions shall be made to bypass 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.

412.5.1 Differential Pressure Bypass Valve. Where a differential pressure bypass valve is used for the purpose specified in Section 412.5, it shall be installed
and adjusted to provide bypass of the distribution system when most or all of the zones are closed.

412.6 Air-Removal Device. Provision shall be made for the removal of air from fluid in hydronic systems. Air-removal devices shall be located in the areas of the hydronic piping system where air is likely to accumulate. Air-removal devices shall be installed to facilitate their removal for examination, repair, or replacement.

Exception: Drainback type solar thermal systems shall not require an air-removal device.

412.7 Air-Separation Device. To assist with the removal of entrained air, an air-separation device shall be installed in hydronic systems. The device shall be located in accordance with the manufacturer’s installation instructions or at the point of no mechanically-induced pressure change within the hydronic system.

Exception: Air-separation devices shall not be required on solar thermal systems.

412.8 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 408.0, an air-removal device in accordance with Section 412.6, and an air-separation device in accordance with Section 412.7.

413.0 Hydronic Space Heating.

413.1 General. Based on the system design, the heat-distribution units shall be selected in accordance with the manufacturer’s specifications.

413.2 Installation. Heat-distribution units shall be installed in accordance with the manufacturer’s installation instructions and this code.

413.3 Balancing. System loops shall be installed so that the design flow rates are achieved within the system.

413.4 Heat Transfer Fluid. The ignitable flash point of heat transfer fluid in a hydronic piping system shall be a minimum of 50°F (28°C) above the maximum system operating temperature. The heat transfer fluid shall be compatible with the makeup fluid supplied to the system.

414.0 Steam Systems.

414.1 Steam Traps. For other than one-pipe steam systems, each heat-distribution unit shall be supplied with a steam trap that is listed for the application.

414.2 Sloping for Two-Pipe System. Two-pipe steam system piping and heat-distribution units shall be sloped down at not less than ¼ inch per foot (10.4 mm/m) in the direction of the steam flow.

414.3 Sloping for One-Pipe System. One-pipe steam system piping and heat-distribution units shall be sloped down at not less than ¼ inch per foot (10.4 mm/m) towards the steam boiler, without trapping.

414.4 Automatic Air Vents. Steam automatic air vents shall be installed to eliminate air pressure in heat-distribution units on gravity steam piping systems. Air vents shall not be used on a vacuum system.

414.5 Condensate Flow. System piping shall be installed to allow condensate to flow to the condensate receiver or steam boiler, either by gravity or pump-assisted.

414.6 Steam-Distribution Piping. Where multi-row elements are installed in an enclosure, they shall be top fed and piped in parallel down to the steam trap. A single steam trap for each row of heating elements shall be installed. Where the size of the return header is increased by a minimum of one pipe size, a single steam trap shall be permitted to be installed for multiple rows. Where multiple steam unit heaters are installed, an individual steam trap for each unit shall be installed.

415.0 Radiant Heating and Cooling.

415.1 Installation. Radiant heating and cooling systems shall be installed in accordance with the system design.

415.1.1 Manifolds. Manifolds shall be equipped with isolation valves on the supply and return lines. Manifolds shall be capable of withstanding the pressure and temperature of the system. The material of the manifold shall be compatible with the system fluid and shall be installed in accordance with the manufacturer’s installation instructions.

415.2 Radiant Floor Heating. Floor finished surface temperatures shall not exceed the following temperatures for space heating applications:

1. 85°F (29°C) in general occupied applications.
2. 90°F (32°C) in bathrooms, foyers, distribution areas such as hallways and indoor swimming pools.
3. 88°F (31°C) in industrial spaces.
4. 95°F (35°C) in radiant panel perimeter areas, i.e., up to 2.5 feet (762 mm) from outside walls.

The radiant heating system temperature shall not exceed the maximum temperature rating of the materials used in its construction.

415.3 Radiant Cooling Systems. Radiant cooling systems shall be designed to minimize the potential for condensation.

To prevent condensation on any cooled radiant surface, the supply water temperature for a radiant cooling system shall be above the space dew point temperature, or in accordance with the manufacturer’s recommendation.

415.3.1 Minimum Floor Temperatures. The minimum floor surface temperature shall not be less than 66°F (19°C) in general occupied applications.

415.3.2 Chilled Water Supply/Distribution Piping. Chilled water piping, valves, fittings, and manifolds shall be insulated and vapor sealed to prevent surface condensation.

Exception: Piping, valves, fittings, and manifolds used to supply radiant cooling systems and where the water temperature is above the space dew point temperature shall not require insulation.
415.4 Tube Placement. Hydronic radiant system tubing shall be installed in accordance with the manufacturer’s installation instructions and with the tube layout and spacing in accordance with the system design. Except for distribution mains, the individual loop lengths shall be installed with a variance of not more than ±10 percent from the design.

415.5 Tube Length. The maximum loop length of continuous tubing from a supply-and-return manifold shall not exceed the lengths specified by the manufacturer or, in the absence of manufacturer’s specifications, the lengths specified in Table 415.5. Actual loop lengths shall be determined by spacing, flow rate, and pressure drop requirements as specified in the system design.

415.6 Tube Identification. For the purpose of system balancing, each individual loop shall have a tag or label securely affixed to the manifold to indicate the length of the loop, and the room(s) and area(s) served.

<table>
<thead>
<tr>
<th>NOMINAL TUBE SIZE (inches)</th>
<th>MAXIMUM LOOP LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>125</td>
</tr>
<tr>
<td>3/16</td>
<td>200</td>
</tr>
<tr>
<td>3/8</td>
<td>250</td>
</tr>
<tr>
<td>1/2</td>
<td>300</td>
</tr>
<tr>
<td>5/8</td>
<td>400</td>
</tr>
<tr>
<td>3/4</td>
<td>500</td>
</tr>
<tr>
<td>1</td>
<td>750</td>
</tr>
</tbody>
</table>

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

415.7 Poured Floor Structural Concrete Slab Systems. Where tubing is embedded in a structural concrete slab, such tubes shall not be larger in outside dimension than one-third of the overall thickness of the slab and shall be spaced not less than three diameters on center except within 10 feet (3048 mm) of the distribution manifold. The top of the tubing shall be embedded in the slab not less than 2 inches (51 mm) below the surface.

415.7.1 Slab Penetration Tube and Joint Protection. Where embedded in or installed under a concrete slab, tubing shall be protected from damage at penetrations of the slab with protective sleeving approved by the tubing manufacturer. The space between the tubing and sleeving shall be sealed with an approved sealant compatible with the tubing. The tubing at the location of an expansion joint in a concrete slab shall be encased in protective pipe sleeving that covers the tubing not less than 12 inches (305 mm) on either side of the expansion joint or the tubing shall be installed below the slab.

415.7.2 Insulation. Where a poured concrete radiant floor system is installed in contact with the soil, insulation recommended by the manufacturer for such an application and with a minimum R-value of 5 shall be placed between the soil and the concrete; extend to the outside edges of the concrete; and be placed on all slab edges.

415.7.3 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.

415.7.4 Spacing of Tube Fasteners. The maximum spacing between tube fasteners within a concrete floor shall not exceed the spacing specified by the manufacturer or, in the absence of manufacturer’s specifications, 2.5 feet (762 mm).

415.8 Joist Systems and Subfloors. Where tubing is installed below a subfloor, the tube spacing shall be in accordance with the system design and joist space limitations.

Where tubing is installed above or in the subfloor, the tube spacing shall not exceed 12 inches (305 mm) center-to-center for living areas.

Where tubing is installed in the joist cavity, the cavity shall be insulated with not less than R-12 material below the heated space.

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 top of the insulation and the underside of the floor unless a conductive plate is installed in accordance with manufacturer’s instructions.

Where tubing is installed in panels above or in the subfloor and not embedded in concrete, the floor assembly shall be insulated with not less than R-5 material below the tubing when installed over habitable space.

415.9 Wall and Ceiling Panels. Where radiant tubing is installed in the wall or ceiling assembly, the tubing shall be located on the interior side of the insulation to direct the transfer of thermal energy between the tubing and the conditioned space.

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.

415.10 Tubing Fasteners. Tubing that is installed within joist spaces and subfloor system 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.

(3) Plastic rails with integrated tube holders intended for the specific type of tube.

(4) Other fasteners recommended by the manufacturer.

415.11 Radiant Heating and Cooling Panels. Radiant heating and cooling panels shall be installed in accordance with the manufacturer’s installation instructions.

415.11.1 Radiant Wall and Ceiling Panels. Radiant panels attached to wood, steel, masonry, or concrete framing members shall be fastened by means of anchors, bolts, or approved screws of sufficient size and anchor- age to support the loads applied. Panels shall be installed with corrosion-resistant fasteners. Piping systems shall be designed for thermal expansion to prevent the load being transmitted to the panel.

416.0 Indirect-Fired Domestic Hot-Water Storage Tanks.

416.1 General. Domestic hot-water heat exchangers, whether internal or external to the heating appliance, shall be permitted to be used to heat water in domestic hot-water storage tanks. Tanks used to store hot water shall be listed for the intended use and constructed in accordance with nationally recognized standards. A pressure- and temperature-relief valve with a set pressure not exceeding 150 percent of the maximum operating pressure of the system, and at a temperature of 210°F (99°C), shall be installed on the storage tank.

Where the normal operating temperature of the boiler or dual purpose water heater that provides heat input for domestic hot water exceeds 140°F (60°C), a thermostatically controlled mixing valve in accordance with Section 407.3.1 shall be installed to limit the water supplied to the potable hot water system to a temperature of 140°F (60°C) or less. The potable water shall be maintained throughout the system.

417.0 Snow and Ice Melt Systems.

417.1 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 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.

417.2 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. 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. Ethylene glycol shall not be used in one- and two-unit residential systems. Where the hydronic fluid contains a chemical additive, a potable water supply shall be protected in accordance with Section 402.0.

417.2.1 Tube Placement. Snow and ice melt tubing shall be installed in accordance with the manufacturer’s installation instructions and with the tube layout and spacing in accordance with the system design. Except for distribution mains, tube spacing and the individual loop lengths shall be installed with a variance of not more than ±10 percent from the design.

417.2.2 Tube Length. The maximum loop length of continuous tubing from a supply-and-return manifold arrangement shall not exceed the lengths specified by the manufacturer or, in the absence of manufacturer’s specifications, the lengths specified in Table 417.2.2. Actual loop lengths shall be determined by spacing, flow rate, and pressure drop in accordance with the system design.

417.2.3 Multizone Systems. In multizone systems, each zone shall have a tag or label securely affixed to the manifold to indicate the length of the loops and the area(s) served.

### TABLE 417.2.2 MAXIMUM LOOP LENGTHS FOR SNOW AND ICE MELT SYSTEMS

<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 and PEX Tubing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>½</td>
<td>130</td>
<td>150</td>
</tr>
<tr>
<td>¾</td>
<td>225</td>
<td>250</td>
</tr>
<tr>
<td>⅞</td>
<td>300</td>
<td>325</td>
</tr>
<tr>
<td>⅞</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>Copper Tubing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>½</td>
<td>–</td>
<td>140</td>
</tr>
<tr>
<td>⅜</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 and 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 any 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.

417.2.4 Poured Structural Concrete Slab Systems. Where tubes are embedded in a structural concrete slab, such tubes shall not be larger in outside dimension than one-third of the overall thickness of the slab and shall be spaced not less than three diameters on center except within 10 feet (3048 mm) of the distribution manifold. The top of the tubing shall be embedded in the slab not less than 2 inches (51 mm) below the sur- face of the finished concrete slab.
417.2.5 Slab Penetration Tube and Joint Protection. Where embedded in or installed under a concrete slab, tubing shall be protected from damage at penetrations of the slab with protective sleeving recommended by the tubing manufacturer. The space between the tubing and sleeve shall be sealed with a sealant recommended by the tubing manufacturer as compatible with the tubing. The tubing at the location of an expansion joint in a concrete slab shall be encased in a protective pipe sleeve that covers the tubing not less than 12 inches (305 mm) on either side of the joint or the tubing shall be installed below the slab.

417.2.6 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 subgrade and be extended as close as practicable to the outside edges of the concrete.

**Exception:** An approved engineered alternative method of construction in accordance with Section 302.2.

417.2.7 Testing and Flushing. Testing of snow and ice melt systems shall be in accordance with Section 405.2 and flushing shall be in accordance with Section 405.3.

417.3 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.

417.4 Spacing of Tube Fasteners. The maximum spacing between tube fasteners within a concrete area shall not exceed the spacing specified by the manufacturer or, in the absence of manufacturer’s specifications, 2.5 feet (762 mm).

418.0 Piping Installation.

418.1 General. Piping, fittings, and connections shall be installed in accordance with the conditions of their approval and manufacturer’s installation instructions.

418.2 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 80 psi at 180°F (552 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 418.2.1 through Section 418.2.3.

418.2.1 Steel Pipe. Steel pipe shall be welded by electrical arc or oxygen/acetylene method.

418.2.2 Copper Tubing. Copper tubing shall be joined by brazing with filler metals having a melting point not less than 1000°F (538°C).

418.2.3 Plastics. Plastic pipe and tubing shall be installed in continuous lengths or shall be joined by heat fusion methods or other approved fittings in accordance with Table 409.1 and the manufacturer’s installation instructions.

Solvent cement joints shall not be used in embedded applications.

418.3 Pressure Testing. Piping to be embedded in concrete shall be pressure tested in accordance with Section 405.2 prior to pouring concrete. During the pour, the pipe system shall maintain the test pressure of not less than one and one-half times the hydronic system operating pressure and not less than 100 psi (689 kPa). During freezing or the possibility of freezing conditions, testing shall be done with air where permitted by the manufacturer.

418.4 System Drainage. Hydronic piping systems shall be installed to permit the system to be drained. The system shall drain by indirect waste in accordance with Section 316.3. Embedded piping underground or under floors is not required to be designed for draining the system.

418.5 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.

418.6 Clearance to Combustibles. Hydronic piping where the exterior temperature exceeds 250°F (121°C) shall have a clearance of not less 1 inch (25.4 mm) to combustible materials.
CHAPTER 5
SOLAR THERMAL SYSTEMS

501.0 General.
501.1 Applicability. The provisions of this chapter address the construction and installation of solar thermal systems, including components. The solar thermal system shall include the solar collector, thermal storage, system piping and appurtenances.

501.2 Connections. Connections that are required for filling, draining, and flushing shall be readily accessible. Solar thermal systems using liquid as a heat transfer medium shall have means for purging air.

501.3 Stagnation Condition. The solar thermal assembly shall be capable of withstanding stagnant conditions in accordance with the manufacturer’s instructions where high solar flux and no flow occurs.

501.4 Draining. Solar thermal system piping shall be installed to permit draining of the system.

501.5 Materials. Piping, tubing and fitting materials shall comply with Table 409.1 and shall be identified by the manufacturer for the intended application. Joining methods shall be in accordance with Section 410.0. Materials in contact with heat transfer medium shall be approved for such use. Galvanized steel shall not be used for solar thermal piping systems containing antifreeze. Black steel shall not be used in systems with entrapped or entrained air. Unions between dissimilar metals shall comply with Section 305.2 and Section 410.16. The material used shall be capable of withstanding the maximum temperature and pressure of the system.

501.5.1 Plastic. Plastic used in the construction of a solar thermal system shall be installed in accordance with the manufacturer’s installation instructions.

501.5.2 Combustible Materials. Combustible materials shall not be located on or adjacent to construction required to be of noncombustible materials or in fire areas, unless approved by the Authority Having Jurisdiction.

501.5.3 Adhesives. Adhesives used in a solar thermal collector shall not vaporize at the design temperature and shall be identified and approved for the intended use.

501.5.4 Potable Water. Materials in contact with potable water shall comply with NSF/ANSI/CAN 61. Piping in solar systems designed to convey potable water shall be flushed and disinfected in accordance with the plumbing code.

501.5.5 Racks. Dissimilar metals used for racking shall be isolated to prevent galvanic corrosion. Paint shall not be used as a method of isolation.

501.5.6 Fasteners. Mountings and fasteners shall be made of corrosion-resistant materials. Carbon steel mountings and fasteners shall be classified as noncorrosive in accordance with ASME SA194.

501.6 Thermosiphon Systems. The storage tank in a thermosiphon system shall be installed above the collector.

501.7 Water Heating Systems. Solar water heating systems shall be in accordance with IAPMO S1001.1 or ICC 900/SRCC 300. 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.

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.

501.9 Automatic Air Vents. Where installed, automatic air release vents shall be located at high points of the solar thermal system with isolation valves for maintenance and removal in accordance with the system design requirements and manufacturer’s installation instructions.

501.10 Waterproofing. Joints between structural supports and buildings or dwellings, including penetrations made by bolts or other means of fastening, shall be made watertight with approved materials.

501.11 Protection. Solar thermal systems shall be protected from excessive pressures, temperature, and vacuum in accordance with Section 311.0. Where required, freeze protection shall be provided in accordance with Section 501.12.

501.12 Freeze Protection. Unless designed for such conditions, solar thermal systems and components that contain liquid as the heat transfer medium shall be protected from freezing where the ambient temperature is less than 46°F (8°C) by means of fail-safe in accordance with Section 501.12.1 through Section 501.12.6.

501.12.1 Antifreeze. Antifreeze shall be used in accordance with the solar thermal system manufacturer’s instructions.

501.12.2 Drainback. Drainback systems shall drain by gravity and shall be permitted to be installed in applications where the ambient temperature is not less than -60°F (-51°C).

501.12.3 Integral Collector Storage. Integral collector storage systems shall be permitted to be installed in applications where the ambient temperature is not less than 23°F (-5°C) and the duration of a below-freezing episode has not exceeded 18 hours. Exposed piping in a solar thermal system shall be protected with insulation having a thermal resistance of not less than R-5.

501.12.4 Indirect Thermosiphon. Indirect thermosiphon systems shall be permitted to be installed in applications where the ambient temperature is not less than 23°F (-5°C). Exposed piping in a solar thermal system shall be protected with insulation having a thermal resistance of not less than R-5.
501.12.5 Labeling. A label indicating the method of freeze protection for the system shall be attached to the system in a visible location.

501.12.6 Piping. Fittings, pipe slopes, and collectors shall be designed and installed to allow for manual gravity draining of solar thermal system components and piping. Collector header pipes or absorber plate riser tubes internal to the collector shall be sloped in accordance with the manufacturer’s instructions. Where a means to drain the system is provided a drain valve shall be installed.

501.13 Circulators. Circulating pumps shall be installed in accordance with Section 310.0. For drainback systems, the pump shall overcome the total head of the system while maintaining the required collector flow rate. For other systems, the pump shall overcome the friction head of the system while maintaining the required collector flow rate.

501.14 Flash Points. The flash point of a heat-transfer medium shall be 50°F (28°C) or more above the design maximum temperature.

501.15 Storage Tanks. Storage tanks shall comply with Chapter 6 and be installed in accordance with the manufacturer’s installation instructions. Access ports and connections shall be accessible.

501.16 Heat Transfer Fluid. Solar thermal piping shall be identified with an orange background with black uppercase lettering, with the words “CAUTION: HEAT TRANSFER FLUID, DO NOT DRINK.” Each solar thermal system shall be identified to designate the fluid being conveyed. The minimum size of the letters and length of the color field shall comply with Table 404.3.

Each outlet on the solar thermal piping system shall be posted with black uppercase lettering as follows: “CAUTION: HEAT TRANSFER FLUID, DO NOT DRINK.”

502.0 Solar Collectors.

502.1 General. Frames and braces exposed to the weather shall be constructed of materials for exterior locations, and protected from corrosion or deterioration, in accordance with the Authority Having Jurisdiction.

502.1.1 Construction. Collectors shall be designed and constructed as to prevent interior condensation, outgassing, or other processes that will reduce the transmission properties of the glazing, reduce the efficiency of the insulation, or otherwise adversely affect the performance of the collector.

502.2 Fire Safety Requirements. Collectors that function as building components shall be in accordance with the building code and the fire code.

502.3 Flat Plate Collector Glass. Flat plate collector glass shall be tempered.

502.4 Air Collectors. Materials exposed within air collectors shall be noncombustible or shall have a flame spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested as a composite product in accordance with ASTM E84 or UL 723.

502.4.1 Testing. Materials used within an air collector shall not smoke, smolder, glow, or flame where tested in accordance with ASTM C411 at temperatures exposed to in service. In no case shall the test temperature be less than 250°F (121°C).

502.5 Installation. Solar collectors shall be ballasted or anchored to roof structures or other surfaces in accordance with Section 317.1. Collectors shall be mounted as to minimize the accumulation of debris. Connecting pipes shall not be used to provide support for a solar collector. Collectors shall be installed in accordance with the manufacturer’s installation instructions.

502.5.1 Protection Against Decay. Wood shall not be used in the construction of collector or system mounting.

502.5.2 Roof Installations. Anchors secured to and through a roofing material shall be made to maintain the water integrity of the roof covering. Roof drainage shall not be impaired by the installation of collectors. Solar collectors that are not an integral part of the roofing system shall be installed to preserve the integrity of the roof surface.

502.5.3 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:
      (i) Plastic CC1 – 33 1⁄3 percent of the roof area.
      (ii) 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.

502.5.4 Ground Installations. Solar collectors shall terminate above finished grade to avoid being obstructed by vegetation, snow, or ice. The supporting columns shall extend below the frost line.

502.5.5 Wall Mounted. Solar collectors that are mounted on a wall shall be secured and fastened in an approved manner in accordance with Section 317.0.

502.5.6 Access. Access shall be provided to collectors and components in an approved manner. A work space adjacent to collectors for maintenance and repair shall be provided in accordance with the Authority Having Jurisdiction.
502.5.7 Orientation. Collectors shall be located and oriented in accordance with the manufacturer’s installation instructions.

502.6 Listing. Collectors that are manufactured as a complete component shall be listed and labeled by an approved listing agency in accordance with ICC 901/SRCC 100, UL 1279, or equivalent standard.

502.7 Disposal and/or Reuse. Solar thermal collectors shall be disposed of or reused in accordance with the Authority Having Jurisdiction.

503.0 Insulation.

503.1 General. The temperature of surfaces within reach of building occupants shall not exceed 140°F (60°C) unless they are protected by insulation. Where sleeves are installed, the insulation shall continue full size through them.

Coverings and insulation used for piping shall be of material approved for the operating temperature of the system and the installation environment. Where installed in a plenum, the insulation, jackets and lap-seal adhesives, including pipe coverings and linings, shall have a flame spread index not to exceed 25 and a smoke-developed index not to exceed 50 where tested in accordance with ASTM E84 or UL 723.

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 installed shall have an R-value of not less than R-2.6 degree Fahrenheit hour square foot per British thermal unit (°F•h•ft²/Btu) (R-0.46 m⁻²•K/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.

503.3 Piping. Pipe and fittings, other than unions, flanges, or valves, shall be insulated. Insulation material shall be approved for continuous operating temperatures of not less than 220°F (104°C).

503.4 Fittings. Fittings shall be insulated with mitered sections, molded fittings, insulating cement, or flexible insulation.

503.5 Installation. Insulation shall be finished with a jacket or facing with the laps sealed with adhesives or staples so as to secure the insulation on the pipe. Insulation jacket seams shall be on the underside of the piping and shall overlap in accordance with the manufacturer’s installation instructions. Joints and seams shall be sealed with a sealant that is approved for both the material and environmental conditions. In lieu of jackets, molded insulation shall be secured with approved fasteners.

503.5.1 Exterior Applications. Insulation for exterior applications shall be finished with an approved jacket, coating, or facing with the surfaces and laps sealed. Jacketing, coating, facing, and tape used for exterior applications shall be designed for such use. Where flexible insulation is used, it shall be wrapped and sealed against water penetration. Insulation used for exterior applications shall be resistant to extreme temperatures, UV exposure, and moisture.

503.6 Ducts. Circulating air ducts shall be insulated in accordance with Table 503.6.

504.0 Testing.

504.1 Piping. The piping of the solar thermal system shall be tested with water, air, heat transfer liquid, or as recommended by the manufacturer’s instructions, except that plastic pipe shall not be tested with air. The Authority Having Jurisdiction shall be permitted to require the removal of plugs, etc., to ascertain where the pressure has reached all parts of the system.

504.2 System Requirements. Prior to the installation of insulation and startup, a solar thermal system, including piping, collectors, heat exchangers, and other related equipment, shall be tested and proved airtight.

504.2.1 Direct (Open-Loop) Systems. Direct (open-loop) systems shall be tested under a water pressure not less than one and one-half times the maximum design operating pressure or 150 pounds-force per square inch (psi) (1034 kPa), whichever is more. Systems shall withstand the test without leaking for a period of not less than 15 minutes.

504.2.2 Indirect (Closed-Loop) Systems. Indirect (closed-loop) systems shall be hydrostatically tested at one-and-one-half times the maximum designed operating pressure in accordance with the manufacturer’s installation instructions. Systems shall withstand the test without leaking for a period of not less than 15 minutes.

505.0 Swimming Pools, Spas, and Hot Tubs.

505.1 Water Chemistry. Where water from a swimming pool, spa or hot tub is heated by way of circulation through solar collectors, the chemistry of such water shall comply with the requirements of Section 505.2, and shall be filtered in accordance with Section 505.3 and Section 505.3.1.

505.2 Parameters. Parameters for chemicals used within a swimming pool, spa, or hot tub shall be in accordance with Table 505.2.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ACCEPTABLE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Hardness</td>
<td>200 – 400 parts per million (ppm)</td>
</tr>
<tr>
<td>Langelier Saturation Index</td>
<td>0 (+ or - 0.3 acceptable)</td>
</tr>
<tr>
<td>pH</td>
<td>7.2 – 7.8</td>
</tr>
<tr>
<td>TDS</td>
<td>&lt; 1500 ppm</td>
</tr>
<tr>
<td>Total Alkalinity</td>
<td>80 – 120 ppm</td>
</tr>
</tbody>
</table>
505.3 Filter. A filter shall be provided to remove debris from the water entering the solar loop. **Exception:** A solar swimming pool, spa, or hot tub heating system with a heat exchanger.

505.3.1 Location. A filter shall be located upstream of a pump used to direct water to solar collectors.

505.4 Corrosion Resistant. Glazed solar collectors made of copper shall not be used for solar pool, spa, or hot tub heating. **Exception:** Where a heat exchanger is provided between the collector circuit and the swimming pool, spa, or hot tub water.

### TABLE 503.6
**INSULATION OF DUCTS**

<table>
<thead>
<tr>
<th>DUCT LOCATION</th>
<th>INSULATION TYPES MECHANICALLY COOLED</th>
<th>HEATING ZONES</th>
<th>INSULATION TYPES HEATING ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>On roof or on exterior of building</td>
<td>C, V² and W</td>
<td>I, II, III</td>
<td>A and W, B and W, C and W</td>
</tr>
<tr>
<td>Attics, and garages and crawl spaces</td>
<td>A and V²</td>
<td>I, II, III</td>
<td>A</td>
</tr>
<tr>
<td>In walls, within floor-ceiling spaces</td>
<td>A and V²</td>
<td>I, II, III</td>
<td>A</td>
</tr>
<tr>
<td>Within the conditioned space, or in basements; return ducts in air plenums</td>
<td>None required</td>
<td>—</td>
<td>None required</td>
</tr>
<tr>
<td>Cement slab or within ground</td>
<td>None required</td>
<td>—</td>
<td>None required</td>
</tr>
</tbody>
</table>

**Notes:**

1. Heating Degree Days:
   a. Zone I – below 4500 Degree Days
   b. Zone II – 4501 Degree Days to 8000 Degree Days
   c. Zone III – exceeds 8000 Degree Days

2. Vapor barriers shall be installed on supply ducts in spaces vented to the outside in geographic areas where the average July, August, and September mean dew point temperature exceeds 60°F (16°C).

3. Insulation shall be permitted to be omitted on that portion of a duct that is located within a wall or a floor-ceiling space where:
   a. Both sides of the space are exposed to conditioned air.
   b. The space is not ventilated.
   c. The space is not used as a return plenum.
   d. The space is not exposed to unconditioned air. Ceilings that form plenums need not be insulated.

4. The examples of materials listed under each type of insulation is not meant to limit other available thickness and density combinations with the equivalent installed conductance or resistance based on the insulation only.

5. Where ducts are used for both heating and cooling, the minimum insulation shall be as required for the most restrictive condition.
CHAPTER 6
THERMAL STORAGE

601.0 General.
601.1 Applicability. This chapter shall govern the construction, design, location, and installations a thermal storage. Thermal storage includes storage tanks with or without heat exchangers and expansion tanks.

601.2 Test Pressure for Storage Tanks. The test pressure for storage tanks that are subject to water pressure from utility mains (with or without a pressure reducing valve) shall be two times the working pressure but not less than 300 psi (2068 kPa).

601.2.1 Pressure Type. Pressure-type storage tanks exceeding 15 pounds-force per square inch (psi) (103 kPa) shall be tested in accordance with ASME BPVC Section VIII.1. Pressure-type storage tanks not exceeding 15 psi (103 kPa) shall be hydrostatically tested at one and one-half times the maximum design operating pressure.

601.2.2 Atmospheric-Type. Atmospheric-type thermal storage tanks shall be tested by filling with water for a period of 24 hours prior to inspection and shall withstand the test without leaking. No thermal storage tank or portion thereof shall be covered or concealed prior to approval.

601.3 Storage Tank Connectors. Flexible metallic storage tank connectors or reinforced flexible storage tank connectors connecting a storage tank to the piping system shall be in accordance with the applicable standards referenced in Table 901.1. Copper or stainless steel flexible connectors shall not exceed 24 inches (610 mm) in length. PEX, PEX-AL-PE, PE-AL-PE, or PE-RT tubing shall not be installed within the first 18 inches (457 mm) of piping connected to a storage tank.

602.0 Insulation.
602.1 Thickness. Tank insulation shall have a thermal resistance not less than as shown in Table 602.1. The temperature difference shall be calculated as the difference between the design operating temperature of the tank and the temperature of the surrounding air, or soil where the tank is installed underground. Where such data is not available, a temperature difference of 50°F (28°C) shall be used.

<table>
<thead>
<tr>
<th>TEMPERATURE DIFFERENCE (°F)</th>
<th>THERMAL RESISTANCE (R) [(°F•h•ft²)/(Btu)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>100</td>
<td>12</td>
</tr>
<tr>
<td>150</td>
<td>18</td>
</tr>
<tr>
<td>200</td>
<td>24</td>
</tr>
<tr>
<td>250</td>
<td>30</td>
</tr>
</tbody>
</table>

For SI units: °C = °F(0.5555556), 1 degree Fahrenheit hour square foot per British thermal unit = [0.176 (m²•K)/W], 1 British thermal unit inch per degree Fahrenheit hour square feet = 0.1441 W/(m²•K)

* Based on thermal conductivity (k) of 0.20 [Btu•inch]/(°F•h•ft²] (0.03 W/(m•K))

603.0 Storage Tanks.
603.1 Plans. Plans for tanks shall be submitted to the Authority Having Jurisdiction for approval, unless listed by an approved listing agency. Such plans shall show dimensions, reinforcing, structural calculations, and such other pertinent data as required.

603.2 Atmospheric Tanks. Atmospheric storage tanks shall be vented to the atmosphere and installed in accordance with the manufacturer’s installation instructions.

603.2.1 Overflow. Gravity tanks shall be installed with an overflow opening of not less than 2 inches (50 mm) in diameter. The openings shall be aboveground and installed with a screened return bend.

603.2.2 Makeup Water. Makeup water from a potable water system to an atmospheric tank shall be protected by an air gap.

603.2.3 Draining. An overflow shall be provided for an atmospheric tank. The overflow shall be provided with a means of drainage in accordance with Section 316.0. The overflow for an atmospheric tank containing nonpotable water shall be emptied into an approved container.

603.3 Prefabricated Tanks. Prefabricated tanks shall be listed and labeled.

603.4 Separate Storage Tanks. For installations with separate storage tanks, a pressure relief valve and temperature relief valve or combination thereof shall be installed on both the main storage and auxiliary storage tank.

603.4.1 Isolation. Storage tanks shall be provided with isolation valves for servicing.

603.5 Underground Tanks. Tanks shall be permitted to be buried underground where designed and constructed for such installation.

603.6 Pressure Vessels. A pressure-type storage tank exceeding an operating pressure of 15 pounds-force per square inch (psi) (103 kPa) shall be constructed in accordance with ASME BPVC Section VIII.1. Fiber-reinforced plastic storage tanks shall be constructed in accordance with ASME BPVC Section X.

603.7 Devices. Devices attached to or within a tank shall be accessible for repair and replacement.

603.7.1 Safety Devices. Pressure-type thermal storage tanks shall be installed with a listed combination temperature and pressure relief valve in accordance with Section 311.1. The temperature setting shall not exceed 210°F (99°C) and the pressure setting shall not exceed 150 percent of the maximum designed operating pressure of the system, or 150 percent of the established normal operating pressure of the piping materials, or the labeled maximum operating pressure of a pressure-type storage tank, whichever is less. The pressure and temperature setting shall not exceed the pressure and tem-
Temperature rating of the tank or as recommended by the tank manufacturer.

Storage tanks and bottom fed tanks connected to a water heater shall be designed to withstand vacuum induced pressure, or shall be provided with a vacuum relief in accordance with Section 311.4. The vacuum relief valve shall be installed at the top of the tank and shall have an operating pressure not to exceed 200 psi (1379 kPa) and a temperature rating not to exceed 250°F (121°C). The size of such vacuum relief valves shall have a minimum rated capacity for the equipment served. This section shall not apply to pressurized captive air diaphragm or bladder tanks.

603.8 Tank Covers. Tank covers shall be structurally designed to withstand anticipated loads and pressures in accordance with the manufacturer’s instructions.

604.0 Materials.

604.1 General. Tanks shall be constructed in accordance with Section 604.2 through Section 604.5.

604.2 Construction. Tanks shall be constructed of durable materials not subject to excessive corrosion or decay and shall be watertight. Each such tank shall be structurally designed to withstand anticipated loads and pressures and shall be installed level and on a solid bed.

604.3 Concrete. The walls and floor of each poured-in-place concrete tank shall be monolithic. The exterior walls shall be double-formed so as to provide exposure of the exterior walls during the required water test. The compressive strength of a concrete tank wall, top and covers, or floor shall be not less than 2500 pounds-force per square inch (psi) (17.236 E+04 kPa). Where required by the Authority Having Jurisdiction, the concrete shall be sulfate resistant (Type V Portland Cement).

604.4 Metal Tanks. Metal tanks shall be welded, riveted and caulked, brazed, bolted, or constructed by use of a combination of these methods.

604.5 Filler Metal. Filler metal used in brazing shall be non-ferrous metal or an alloy having a melting point above 1000°F (538°C) and below that of the metal joined.

605.0 Expansion Tanks.

605.1 Where Required. An expansion tank shall be installed in a water heating system as a means for controlling increased pressure caused by thermal expansion. Expansion tanks shall be of the closed type and securely fastened to or supported by the structure. Tanks shall be rated for the pressure of the system. Supports shall be capable of carrying twice the weight of the tank filled with water without placing strain on the connecting piping.

Water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

Exception: An engineered fluid expansion storage system shall be permitted to incorporate fluid storage in vessels open to the atmosphere. Storage tanks and components for such systems shall be constructed of non-corrosive materials, or the system fluid shall be treated to inhibit corrosion. [See Figure 408.1(2) for an example of an engineered fluid expansion storage system which incorporates fluid storage in a vessel open to the atmosphere.]

605.2 Closed-Type Systems. Closed-type systems shall have an airtight tank or other approved air cushion that will be consistent with the volume and capacity of the system, and shall be designed for a hydrostatic test pressure of two and one-half times the allowable working pressure of the system. Expansion tanks for systems designed to operate at more than 30 pounds-force per square inch (psi) (207 kPa) shall comply with ASME BPVC Section VIII.1. Provisions shall be made for draining the tank without emptying the system.

605.3 Minimum Capacity of Closed-Type Tanks. The minimum capacity for a gravity-type hot water system expansion tank shall be in accordance with Table 605.3(1). The minimum capacity for a forced-type hot water system expansion tank shall be in accordance with Table 605.3(2) or Equation 605.3(1). The minimum capacity for diaphragm tanks shall be in accordance with Table 605.3(2) or Equation 605.3(2).

\[ V_t(\text{forced type}) = \frac{(C_1 t - C_2) V_s}{(P_a - P_f)/P_o} \]  
\[ V_t(\text{diaphragm}) = \frac{(C_1 t - C_2) V_s}{1 - P_f/P_o} \]

Where:

- \( C_1 = 0.00041 \)
- \( C_2 = 0.0466 \)
- \( V_t = \) Minimum volume of expansion tank, gallons (L)
- \( V_s = \) Volume of system, not including expansion tank, gallons (L)
- \( t = \) Average operating temperature, °F (°C).
- \( P_a = \) Atmospheric pressure, pounds per square inch (kPa)
- \( P_f = \) Fill pressure, pounds per square inch (kPa)
- \( P_o = \) Maximum operating pressure, pounds per square inch (kPa)

For SI units: \( C_1 = 0.000738, \ C_2 = 0.03348, \) 1 gallon = 3.785 L, °C = (°F - 32)/1.8, 1 pound per square inch = 6.8947 kPa

606.0 Dry Storage Systems.

606.1 Waterproofing. The containment structure for dry thermal storage systems shall be constructed in an approved manner to prevent the infiltration of water or moisture.
**606.2 Detecting Water Intrusion.** The containment structure shall be capable of fully containing spillage or moisture accumulation that occurs. The structure shall have a means, such as a sight glass, to detect spillage or moisture accumulation, and shall be fitted with a drainage device to eliminate spillage.

**606.3 Rock as Storage Material.** Systems utilizing rock as the thermal storage material shall use clean, washed rock, and free of organic material.

<table>
<thead>
<tr>
<th>INSTALLED EQUIVALENT DIRECT RADIATION (square feet)</th>
<th>TANK CAPACITY (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 350</td>
<td>18</td>
</tr>
<tr>
<td>Up to 450</td>
<td>21</td>
</tr>
<tr>
<td>Up to 650</td>
<td>24</td>
</tr>
<tr>
<td>Up to 900</td>
<td>30</td>
</tr>
<tr>
<td>Up to 1100</td>
<td>35</td>
</tr>
<tr>
<td>Up to 1400</td>
<td>40</td>
</tr>
<tr>
<td>Up to 1600</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 1800</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 2000</td>
<td>2 to 35</td>
</tr>
<tr>
<td>Up to 2400</td>
<td>2 to 40</td>
</tr>
</tbody>
</table>

For SI units: 1 gallon = 3.785 L, 1 square foot = 0.0929 m²

**Notes:**
1. Based on a two-pipe system with an average operating water temperature of 170°F (77°C), using cast-iron column radiation with a heat emission rate of 150 British thermal units per square foot hour (Btu/(ft²•h)) (473 W/m²) equivalent direct radiation.
2. For systems exceeding 2400 square feet (222.9 m²) of installed equivalent direct water radiation, the required capacity of the cushion tank shall be increased on the basis of 1 gallon (4 L) tank capacity per 33 square feet (3.1 m²) of additional equivalent direct radiation.

<table>
<thead>
<tr>
<th>SYSTEM VOLUME (gallons)</th>
<th>TANK CAPACITY DIAPHRAGM TYPE (gallons)</th>
<th>TANK CAPACITY (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>200</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>300</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>400</td>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td>500</td>
<td>42</td>
<td>75</td>
</tr>
<tr>
<td>1000</td>
<td>83</td>
<td>150</td>
</tr>
<tr>
<td>2000</td>
<td>165</td>
<td>300</td>
</tr>
</tbody>
</table>

For SI units: 1 gallon = 3.785 L

**Notes:**
1. Based on an average operating water temperature of 195°F (91°C), a fill pressure of 12 psig (83 kPa), and an operating pressure of not more than 30 psig (207 kPa).
2. Includes volume of water in boiler, radiation, and piping, not including expansion tank.

**606.4 Odor and Particulate Control.** Thermal storage materials and containment structures, including an interior protective coating, shall not impart toxic elements, particulate matter, or odor to areas of human occupancy.

**606.5 Combustibles Within Ducts or Plenums.** Materials exposed within ducts or plenums shall be noncombustible or shall have a flame spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested as a composite product in accordance with ASTM E84 or UL 723.

**Exception:** Plastic pipe and tubing listed and labeled for use in plenums in accordance with UL 2846 as having a peak optical density not greater than 0.50, an average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet (1524 mm), and installed in accordance with its listing, shall be permitted.

**TABLE 605.3(1)**

**EXPANSION TANK CAPACITIES FOR GRAVITY HOT WATER SYSTEMS**

**TABLE 605.3(2)**

**EXPANSION TANK CAPACITIES FOR FORCED WATER SYSTEMS**

**THERMAL STORAGE**
CHAPTER 7
GEOTHERMAL ENERGY SYSTEMS AND DISTRICT GEOThERMAL LOOPS

Part I - General.

701.0 General.

701.1 Applicability. Part I of 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.

Part I through Part V of this chapter shall apply to geothermal energy systems and district systems that circulate ground-ambient-temperature water, conditioned water, or heat transfer fluid, to be used in end-use buildings as a thermal source or sink via water source heat pump or reversing chiller. The systems shall operate to permit independent and bi-directional heating and cooling for comfort and water heating such as, but not limited to, building systems with ground coupled district loops, including ambient temperature loops (ATL), a ground-heat exchanger, submerged heat exchanger using water-based fluid as a heat transfer medium, or groundwater (well), or such local energy resources to the advantage of the district. Central district auxiliary components shall add or reject heat to benefit district ability to reduce both power consumption and demand combined with energy sharing.

The regulations of this chapter shall govern the construction, location, and installation of ground temperature thermal distribution districts from 100 percent geothermal energy systems to multiple hybrid district systems, including systems which utilize multiple hybrid district systems and components.

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.

701.1.2 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.

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

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

701.3 Site Survey. A site survey shall be conducted prior to designing the geothermal system. The requirements for construction documents shall be defined by the Authority Having Jurisdiction. Where no guidance is provided, the following information shall be provided: the construction documents shall include a plat plan indicating the following:

1. Ground heat exchanger dimensions.
2. Grout or sealing specifications, as applicable.
3. Dimensions from building to water well, ground heat exchanger, or submerged heat exchanger.
4. Operating temperatures and pressures.
5. The dimension and location of the ground or submerged heat exchanger.
6. The distance from the structure to the ground or submerged heat exchanger.
7. The configuration and depth of the ground or submerged heat exchanger.
8. The distance to any utility and sanitary features that exist near the ground or submerged heat exchanger.

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 Heat Transfer Fluid. The heat transfer fluid shall be compatible with the makeup fluid supplied to the system.

701.11.1 Water Quality. The makeup water quality within the closed-loop ground source heat pump system shall be in accordance with IAPMO/ANSI H1001.1, ANSI/CSA/IGSHPA C448, or Table 701.11.1. The quality of potable water shall be in accordance with the Authority Having Jurisdiction.

701.11.2 Compatibility. System components shall be compatible with system fluids including, but not limited to, antifreeze. For systems utilizing chemical additives, system components and fluids shall be tested and identified for compatibility.

702.0 Groundwater Systems.

702.1 General. The potable water supply connected to a groundwater system shall be protected with an approved backflow prevention device. The connection of a discharge line to the sanitary or storm sewer system, or private sewage disposal system, shall be in accordance with the plumbing code or in accordance with the Authority Having Jurisdiction.

703.0 Design of Systems.

703.1 Ground-Heat Exchanger Design. The ground-heat exchanger design shall be provided by a licensed professional or a designer with the appropriate certifications or credentials as defined by the Authority Having Jurisdiction.

703.2 Piping and Tubing Material 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.

703.3 Fittings. For water-based systems, fittings for ground source heat pump systems shall be identified 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.

703.4 Underground Piping and Submerged Materials. Underground and submerged piping for a ground-heat exchanger shall be polyethylene (PE) pipe or tubing in accordance with Section 703.4.1 and Section 703.4.1.1, polyethylene of raised temperature (PE-RT) pipe or tubing in accordance with Section 703.4.2 and Section 703.4.2.1, or cross-linked polyethylene (PEX) pipe or tubing in accordance with Section 703.4.3 and Section 703.4.3.1.

703.4.1 Polyethylene (PE). Polyethylene pipe or tubing shall be manufactured in accordance with the standards listed in Table 703.2. Pipe or tubing shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Polyethylene pipe or tubing shall be manufactured from a PE compound that has a pipe material designa-
tion code of PE 3608 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 AWWA C901. Polyethylene pipe or tubing shall have a minimum wall thickness in accordance with Table 703.4.1.

**Exception:** HDPE lateral piping with a minimum pressure rating of 100 psi (689 kPa) at 73°F (23°C) shall not be required to have a minimum wall thickness in accordance with Table 703.4.1.

703.4.1.1 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 heat fusion methods:

1. Butt-fusion joints shall be made in accordance with ASTM F2620.
2. Socket-fusion joints shall be made in accordance with ASTM F2620.
3. Electrofusion joints shall be made in accordance with ASTM F1055.

**TABLE 703.4.1**

<table>
<thead>
<tr>
<th>PE PIPE AND TUBING MINIMUM WALL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PE PIPE MATERIAL</strong></td>
</tr>
<tr>
<td>PE 3608</td>
</tr>
<tr>
<td>PE 4710</td>
</tr>
</tbody>
</table>

703.4.2 Polyethylene of Raised Temperature (PE-RT). Polyethylene of raised temperature tubing shall be manufactured in accordance with the standards listed in Table 703.2. Tubing shall have a minimum wall thickness equal to SDR 9 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Polyethylene of raised temperature tubing shall be manufactured from a PE compound that has a pipe material designation code of PE 2708, PE 3608, 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.

703.4.2.1 Joining Methods for Polyethylene of Raised Temperature (PE-RT). Joints between polyethylene of raised temperature (PE-RT) tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions and the appropriate standards listed in accordance with Table 703.3.

703.4.3 Cross-Linked Polyethylene (PEX). Cross-linked polyethylene pipe shall be manufactured in accordance with the standards listed in Table 703.2. PEX shall have a minimum tubing material designation code of PEX 1206 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

703.4.3.1 Joining Methods for Cross-Linked Polyethylene Pipe or Tubing. Joints between cross-linked polyethylene (PEX) pipe or tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions and the appropriate standards in accordance with Table 703.3.

703.5 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.

704.0 Heat Pumps.

704.1 Heat Pump Distribution System. The heat pump distribution system shall be designed as follows:

1. Individual heat pumps shall have the capacity to handle the peak load for each zone at its peak hour.
2. Distribution piping and fittings shall be insulated to prevent condensation inside the building.
3. An isolation valve shall be installed on both supply and return of each unit.
4. Condensate drains on heat pumps shall be installed in accordance with the manufacturer’s installation instructions.
5. Air filters shall be installed for heat pump units.
6. Drain valves shall be installed at the base of each supply and return pipe riser for system flushing.
7. Piping shall be supported in accordance with Section 317.0 and provisions for vibration, expansion or contraction shall be provided.
8. Specifications for each heat pump, the heating and cooling capacity, the fluid flow rate, the airflow rate, and the external pressure or head shall be provided on the construction documents.
9. Manually controlled air vents shall be installed at the high points in the system and drains at the low points. Where the heat-transfer fluid is a salt or alcohol, automatic air vents shall not be installed.
10. Means for flow balancing for the building loop shall be provided.
11. Supply and return header temperatures and pressures shall be marked.

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

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 705.9.
705.2 Heat Exchangers. Shutoff valves shall be installed on the supply and return side of a heat exchanger.

Exception: Where the heat exchanger is integral with a boiler or is a component of a manufacturer’s boiler and heat exchanger packaged unit, and is capable of being isolated from the hydronic system by the 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.

Exception: Shutoff valves shall not be required for individual geothermal ground-loops.

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.

705.9 Bypass Valves. Means shall be provided to allow for bypass of the geothermal system for independent flushing and purging of the geothermal system and building-piping system.

706.0 Specific System Components Design.

706.1 General. Heat pumps shall be in compliance with Table 706.1, as applicable. Heat pumps shall also comply with UL 1995 or UL 60335-2-40. Ground coupled and water source heat pumps shall be listed 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 listed 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.

<table>
<thead>
<tr>
<th>TYPE OF HEAT PUMP</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-to-Air</td>
<td>AHRI/ASHRAE/ISO 13256-1</td>
</tr>
<tr>
<td>Water-to-Water</td>
<td>AHRI/ASHRAE/ISO 13256-2</td>
</tr>
</tbody>
</table>

706.2 Heat Exchangers. Heat exchangers used for heat transfer or heat recovery shall protect the potable water system from being contaminated by the heat transfer medium. Single-wall heat exchangers shall comply with Section 313.1. Double-wall heat exchangers shall separate the potable water from the heat transfer medium by providing a space between the two walls that are vented to the atmosphere.

706.3 Heat-Transfer Medium. The heat-transfer medium shall be compatible with components with which it comes into contact. Where antifreeze or corrosion inhibitors are used, such solutions shall be approved by the Authority Having Jurisdiction. The heat-transfer fluid flash point shall be not less than 50°F (28°C) above the maximum system operating temperature. For DX systems, the heat transfer medium shall be a refrigerant listed in ASHRAE 34 or the mechanical code. For six-pipe heat pump systems and other specialty heat pumps that comingle source and load fluids, the manufacturer’s installation instructions shall apply.

706.4 Insulation. The temperature of surfaces within reach of building occupants shall not exceed 140°F (60°C) unless they are protected by insulation. Where sleeves are installed, the sleeve insulation shall retain its full size over the length of the material being protected.

707.0 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 identified 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 or certified designer 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.
707.6 Ground Heat-Exchanger Installation Practices. A ground-heat exchanger system shall be installed in accordance with the following:

(1) Outside piping or tubing located within 5 feet (1524 mm) of any wall or structure shall be continuously insulated with insulation that has a minimum R-5 value. Such pipe or tubing installed under the slab or basement floors shall be insulated within 5 feet (1524 mm) from the structure to the exterior point of exit from the slab.

(2) Freeze protection shall be provided where the design of the ground heat exchanger system would permit the heat-transfer medium to freeze.

(3) Horizontal piping shall be installed not less than 12 inches (305 mm) below the frost line.

(4) Submerged heat exchangers shall be protected from damage and shall be securely fastened to the bottom of the lake or pond, or other approved submerged structure.

(5) A minimum separation distance shall be maintained between the potable water intake and the submerged heat exchanger system in accordance with the Authority Having Jurisdiction. Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

707.7 Setbacks. In absence of minimum setbacks specified by the Authority Having Jurisdiction, minimum setbacks for vertical ground-heat exchanger systems shall be maintained in accordance with Section 707.7.1, and minimum setbacks for horizontal ground-heat exchanger systems shall be maintained in accordance with Section 707.7.2.

707.7.1 Vertical Systems. Vertical ground-heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:

(a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.

(b) Fifty feet (15 240 mm) horizontally from a non-pressure tested sewer lateral into a building.

(c) Five feet (1524 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 50 feet (15 240 mm) from a subsurface sewage leaching field.

(f) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.

(g) Wells and boreholes shall be sealed in accordance with the Authority Having Jurisdiction. Where grout is required, it shall be applied in a continuous operation from the bottom of the borehole by pumping through a tremie pipe.

707.7.2 Horizontal Systems. Horizontal ground heat exchangers shall maintain minimum setbacks in accordance with the following, or the Authority Having Jurisdiction:

(a) Five feet (1524 mm) horizontally from a pressure-tested sewer lateral into a building.

(b) Ten feet (3048 mm) horizontally from a non-pressure tested sewer lateral into a building.

(c) Five feet (1524 mm) horizontally from buried utilities such as electrical gas or water.

(d) Ten feet (3048 mm) from a water well.

(e) Ten feet (3048 mm) from a septic tank and 10 feet (3048 mm) from a subsurface leaching field.

707.7-707.8 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.

707.8-707.9 Trenches, Tunneling, and Driving. Trenches shall comply with Section 320.1. Tunneling and driving shall comply with Section 320.2.

707.9-707.10 Excavations and Open Trenches. Excavations required to be made for the installation of piping or tubing shall be in accordance with Section 320.3. Piping or tubing shall be supported to maintain its alignment and prevent sagging. Piping in the ground shall be laid on a firm bed for its entire length; where other support is otherwise provided, it shall be approved in accordance with Section 302.0. Piping or tubing shall be backfilled after an inspection in accordance with Section 320.4.

707.10-707.11 Protection of Piping, Materials, and Structures. Piping and tubing passing under or through walls shall be protected from breakage in accordance with Section 318.1. Piping and tubing shall be installed in accordance with Section 318.2 to provide for expansion, contraction, and structural settlement. An electrically continuous corrosion-resistant tracer wire (not less than AWG 14) or tape shall be buried with the plastic pipe to facilitate locating. One end shall be brought aboveground at a building wall or riser.

707.11-707.12 Sleeves. In exterior walls, annular space between sleeves and pipes shall be sealed and made watertight and shall not be subject to a load from building construction in accordance with Section 318.6 through Section 318.6.2.

707.12-707.13 Steel Nail Plates. Steel nail plates shall be installed for plastic and copper piping penetrating framing members to within 1 inch (25.4 mm) of the exposed framing in accordance with Section 318.5.

707.13-707.14 Piping Protection. Prior to system use and during construction, piping shall be fitted with end caps and protected from freezing, UV radiation, corrosion, and degradation.
707.14-707.15 Heat Pump and Distribution System Installation. The heat pump and distribution system shall be installed in accordance with the system’s design, with this code, and the manufacturer’s installation instructions.

707.15-707.16 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.

707.16-707.17 Horizontal Geothermal Piping - Materials and Methods. Horizontal geothermal piping shall be in accordance with Section 707.17.1 through Section 707.18.8.

707.16.1-707.17.1 Piping Materials. 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, and Section 715.3.

707.16.2-707.17.2 Dissimilar Materials. Transition fittings between dissimilar materials shall be inside or accessible.

707.16.3-707.17.3 Protection of Piping. Pipes passing through walls shall be sleeved and sealed in accordance with Section 318.0.

707.17-707.18 Trenches, Excavation, and Backfill. Excavation for horizontal piping shall comply with Section 707.8 through Section 707.10, Section 707.18.1 through Section 707.18.8, 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.

707.17.1-707.18.1 Trenches. Trenches for underground piping or tubing shall be excavated in accordance with the setback requirements in Section 712.4.

707.17.2-707.18.2 Buried Systems. Buried open-loop system piping, shall be installed not less than 3.3 feet (1006 mm) below the finished grade.

707.17.3-707.18.3 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.

707.17.4-707.18.4 Separation. The horizontal piping shall be separated from fluid-based on-site service systems to prevent excessive short-circuiting heat transfer between such systems.

707.17.5-707.18.5 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.

707.17.6-707.18.6 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.

707.17.7-707.18.7 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.

707.17.8-707.18.8 Tracer and Warning 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 1/16 of an inch (1.6 mm) and a width of not less than 3 inches (76 mm) 6 inches (152 mm) and with burial depths in accordance with the manufacturer’s specifications, or non-metallic warning tape used in conjunction with tracer wire that complies with UL 2989.

Tracer and warning markings 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. Tracer wire shall be permitted to be installed at buried pipe grade.

708.0 System Start-Up.

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

(1) To prevent debris in the building piping system from entering the geothermal loop field piping or residual debris from the geothermal loop field entering the building piping, the connection between building piping and the geothermal loop field shall be isolated so as to allow a bypass for the independent cleaning, flushing, and purging of both the loop field as well as the building piping and equipment prior to the introduction of building fluid into the geothermal loop field.

(2) The ground heat exchanger and building piping, 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.

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

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

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

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

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

(9) Supply and return lines on submerged systems shall be identified in an approved manner, at the point of entry to a surface water resource.
708.2 Operation and Maintenance Manual. An operation and maintenance manual for the geothermal system shall be provided to the owner. The manual shall include information on required testing and maintenance of the system. Training shall be provided on the system’s operation, maintenance requirements, and on the content of the operation and maintenance manual. The operation and maintenance manual shall contain a layout of the ground-heat exchanger and building loop.

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 start-up shall be in accordance with ANSI/CSA/IGSHPA C448 and Section 708.0.

708.8 Contaminants. Particulate contaminants shall be removed from the indoor piping system prior to initial start-up.

709.0 Decommissioning and Abandonment.

709.1 General. Decommissioning of geothermal systems shall comply with ANSI/CSA/IGSHPA C448. Prior to the abandonment or decommissioning of geothermal systems, the owner shall obtain the necessary permits from the Authority Having Jurisdiction.

Part II – Closed-Loop Systems.

710.0 General.

710.1 Applicability. Part II of this chapter shall apply to closed-loop geothermal energy systems such as, but not limited to, building systems coupled with a closed-loop system using water-based fluid as a heat transfer medium systems coupled to a ground loop heat exchanger, or a heat exchanger submerged in a surface body of water. [See Figure 710.1(1) for an example of a simplified schematic of a closed-loop geothermal system coupled to a ground loop heat exchanger. See Figure 710.1(2) for an example of a simplified schematic of a closed-loop geothermal system coupled to a heat exchanger submerged in a surface body of water.]

710.2 Piping and Tubing. Piping and tubing for closed-loop systems shall be in accordance 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 in accordance
with Table 703.4.1 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.

710.5 Bypass Valves. Means shall be provided to allow for bypass of the closed-loop geothermal system for independent flushing and purging of the geothermal system and building piping system.

710.6 Verification. For closed-loop systems, the system shall be flushed of debris and purged of air after completion of the entire ground-heat exchanger. Flow rates and pressure drops shall be compared to calculated values to assure no blockage or kinking of the pipe. A report shall be submitted to the owner to confirm that the loop flow is in accordance with the construction documents.

710.7 Vertical Bores. Vertical bores shall be drilled to a depth to provide complete insertion of the u-bend pipe to its specified depth. The borehole diameter shall be sized for the installation and placement of the heat exchange u-bend and the tremie used to place the grouting material. ANSI/CSA/IGSHPA C448 shall be used for vertical loop depth and borehole diameter sizing guidance. The u-bend joint and pipe shall be visually inspected for integrity in accordance with the manufacturer’s installation instructions. The u-bend joint and pipe shall be pressurized to not less than 100 psi (689 kPa), not to exceed the pressure rating of the pipe at the test temperature, for 1 hour to check for leaks before insertion into the borehole.

710.7.1 Backfill. Bentonite grout and thermally-enhanced bentonite grout, where used to seal and backfill each borehole, shall comply with NSF/ANSI/CAN 60. Boreholes shall be backfilled in accordance with the Authority Having Jurisdiction.

710.7.2 U-Bends and Headers. Headers, u-bends and ground loop pipes shall be pressure-tested in accordance with ANSI/CSA/IGSHPA C448, or as required by the Authority Having Jurisdiction. Before testing, heat fusion joints shall be cooled to ambient temperature. Mechanical joints shall be completely assembled. Flushing and purging to remove air and debris shall be completed before testing. The assembly shall be filled with water (or water/antifreeze solution) and purged at a minimum flow rate of 2 feet per second (0.6 m/s) to remove air, but not more than the maximum flow velocity recommended by the pipe and fittings manufacturer to remove debris.

710.7.2.1 Test Pressure. The maximum test pressure shall be 1.5 times the system design pressure, as determined by Section 710.7.2.3, or Section 710.7.2.4, 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.

710.7.2.2 Testing Procedure. The test section and the test liquid shall be at the same temperature. The test section shall be filled with liquid and purged of air. The test section shall be brought to the specified test pressure. Test pressure shall be maintained for 4 hours, with additional fluid added as needed. The test pressure shall be reduced by 10 psi (69 kPa) and monitored for 1 hour with no addition of pressure or additional fluid. A passing test is indicated where after a period of 1 hour no visual leakage is observed, and pressure remains equal to or greater than 95 percent of the original pressure.

710.7.2.3 Calculation of Static Pressure (Water). For water, the static pressure applied shall be equivalent to 0.43 psig (2.96 kPa) per foot (305 mm) of elevation.

710.7.2.4 Calculation of Static Pressure (Other Fluids). For fluids of different density, the static pressure shall be calculated using the density of the system fluid.

711.0 Ground-Heat Exchanger Testing.

711.1 Testing. Pressure-testing of the ground-heat exchanger shall be performed in accordance with the testing method in Section 710.7.

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.

Part III – Open-Loop Systems.

712.0 General.

712.1 Applicability. Part III of this chapter shall apply to open-loop geothermal energy systems such as, but not limited to, building systems coupled to a source of ground-water (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. Outdoor piping, fittings, and accessories shall be in accordance with Section 702.2.

Components which come into contact with the system fluids and are installed in a geothermal open-loop system shall be constructed of corrosion resistant materials.
accordance with the Authority Having Jurisdiction. Materials which come into contact with potable water shall comply with NSF/ANSI/CAN 61 and NSF/ANSI/CAN 372. [See Figure 712.1(1) for an example of a simplified schematic of an open-loop geothermal system utilizing subsurface water. See Figure 712.1(2) for an example of a simplified schematic of an open-loop geothermal system utilizing surface water.]

712.2 Test Wells. Test wells drilled to investigate subsurface conditions shall provide details of the groundwater location, chemical and physical characteristics, rock strata, and temperature profiles. The number of test wells shall be determined in accordance with the Authority Having Jurisdiction. Each test well shall be tested for flow rate for a period of not less than 24 hours. Water samples shall be collected in accordance with the NGWA-01 from each well to establish existing water quality levels are approved for groundwater system use. Water samples shall be analyzed for standard drinking water, fecal and coliform content, bacterial iron, nitrate, dissolved minerals, pH, hardness, and other compounds in accordance with NGWA-01 or in accordance with the Authority Having Jurisdiction. Wells shall be disinfected upon completion in accordance with NGWA-01 or in accordance with the Authority Having Jurisdiction. A copy of the water quality test results and the log of well construction in accordance with NGWA-01 shall be provided to the owner.

712.3 Installation of Water Wells. Water supply, recharge wells, and pumping equipment shall be hydraulically tested, sealed, and grouted in accordance with approved well construction practices and submitted to the Authority Having Jurisdiction for approval. Wells shall be tested for water production and recovery, water quality before final system design. Wells shall be disinfected upon completion in accordance with NGWA-01 or in accordance with the Authority Having Jurisdiction. A copy of the water quality test results and the log of well construction in accordance with NGWA-01 shall be provided to the owner.

712.4 Setbacks. Open-Geothermal open-loop systems ground-heat exchangers shall maintain separation between supply and discharge locations in accordance with the registered design professional and the following minimum setbacks or at distances specified by the Authority Having Jurisdiction:

1. Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
2. Twenty feet (6096 mm) horizontally from a non-pressure tested sewer lateral into a building.
3. Three feet (914 mm) horizontally from buried utilities such as electrical, gas, or water.
4. Fifty feet (15 240 mm) from a water well.
5. Fifty feet (15 240 mm) from a septic tank and 100 feet (30 480 mm) from a subsurface sewage leaching field.
6. One hundred feet (30 480 mm) from a spring.

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 or certified designer. 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 of 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 onsite 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.

713.4 Water Wells and Injection Wells. Water wells and injection wells for groundwater heat pump systems shall be installed and tested 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 or certified designer.

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

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 or certified designer.

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 or certified designer.

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 or certified designer. 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.

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.
715.3 **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.

715.4 **DX System Testing.** 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 ANSI/CSA/IGSHPA C448.

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.

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.

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.

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

**Part V – Ambient Temperature Loops (ATL) Geothermal.**

716.0 **Ambient Temperature Loop (ATL) Distributed Energy Systems.**

716.1 **General.** An ambient temperature loop (ATL) distributed energy system shall be installed in accordance with Section 716.2 through Section 716.6.3, and Section 717.0. ATL systems shall comply with Part I through Part IV of this chapter, as applicable. (See Figure 716.1 for a schematic of a geothermal system utilizing an ambient temperature loop.)

716.1.1 **Fourth Generation (4G) System Configuration.** A fourth-generation system configuration shall be a district geothermal energy system distributing hot water, cold water, or both to the conditioned space or building for a specific use. Where a geothermal energy source is used, such systems shall comply with Part I through Part IV of this chapter and Chapter 4.

716.1.2 **Fifth Generation (5G) System Configurations.** An advanced ambient temperature loop (ATL) System or fifth generation (5G) ATL system shall also be capable of interacting with the electric utility system as well as other utility systems and systems components.

System components shall include, but not be limited to the following:

1. Thermally diverse buildings with independent hydronic systems.

2. Circulation loop.

3. Global control system.

4. Segment isolation capability.

**Note:** System components may include, but are not limited to, the following:

1. Electric grid-interactive enabled buildings

2. Hybrid components

3. Other renewable systems

716.2 **Permitting.** Permits required for the installation and application of an ATL distributed energy system shall be obtained as required by the Authority Having Jurisdiction.

716.3 **Ambient Loop Temperature Range.** The operating loop temperature range of an ambient temperature loop (ATL) system shall be not less than the freezing point of the circulating fluid and not more than the maximum temperature, as required by the manufacturer’s installation instructions for the attached heat pump equipment in accordance with Section 716.3.1 and Section 716.3.2. The ATL system shall use treated water as the heat transfer medium.

716.3.1 **ATL Operating Temperature.** For equipment listed to AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2, the controlled temperature range of the ambient closed-loop shall be not less than 7°F (4°C) above the freezing point of the transport fluid and 10°F (6°C) below the (collective) heat pump lowest maximum inlet supply temperature as recommended by the manufacturer’s instructions.

**Exception:** Equipment that is not listed to AHRI/ASHRAE/ISO 13256-1 and AHRI/ASHRAE/ISO 13256-2, the controlled temperature range of the ambient closed loop shall be in accordance with Section 716.3.2 for minimum and maximum temperatures.

716.3.2 **ATL Operating Temperature Range for Mixed Equipment Certifications.** The source inlet temperature range of any attached equipment shall govern the design operating temperature range. Such equipment shall be identified in the design documentation. In any case, the most restrictive minimum and maximum inlet supply temperatures, as recommended by the manufacturer’s instructions, shall determine the system operating temperature range.

716.4 **Shutoff Valve.** An automatic shutoff valve shall be provided for each individual building or facility transferring energy to or from an ATL distribution system. The automatic shutoff valve shall automatically shutoff upon operating command.
716.4.1 Shutoff Valve Operation. The operation of the automatic shutoff valve shall be in accordance with the system operating procedures. Where the operation of a shutoff valve was due to an emergency response, an auxiliary heating or cooling methodology shall be provided in accordance with Section 717.1.2.

716.5 Bypass. The ATL distributed energy system shall be provided with bypass path(s) to reroute the circulating fluid when necessary.

716.6 Metering. Where meters are required by the system design, meter(s) shall be located as specified by the manufacturer on each consumptive or supply source, and the range of the metering shall be appropriate to the thermal properties and flow rate(s) of the transport fluid.

716.6.1 Sub-Metering System Specification. The entire energy measurement system shall be provided with a sub-metering system. The metering system shall be calibrated and shall consist of a flow meter, temperature sensors, temperature thermowells, or other required mechanical installation metering. The sub-meter traceable calibration shall comply with a National Institute of Standards Technology (NIST) traceable calibration program or in accordance with the Authority Having Jurisdiction and shall be provided with an ATL distributed energy system.

716.6.2 Btu/Thermal Meters. Where used, the Btu/thermal meter shall be bidirectional and shall provide the following information via digital or analog display:

1. LCD, and via serial network communications.
2. Total energy, Btu (kWh).
3. Energy rate, Btu/h (kW).

* Equipment arrangements and configurations may vary.
Each Btu/thermal meter shall be factory programmed for its specific application and shall be re-programmable to adjust for specific site conditions.

716.6.3 Flow Meter. Where used, the flow meter shall be provided with the following information via digital or analog display:

1. LCD, and via serial network communications.
2. Instantaneous fluid rate, gpm (L/s).
3. Cumulative fluid flow volume, gal (L).

717.0 ATL Distributed Energy Systems Design Requirements.

717.1 Thermal Resources. The ambient temperature loop (ATL) shall be permitted to connect to a thermal resource(s). Such resources may be an alternative energy source and sink, such as but not limited to, solar photovoltaic (PV), solar thermal, combined heat power (CHP), and phase change thermal storage. These systems shall be installed and comply with the respective system requirements. ATL distributed energy systems coupled with solar thermal systems shall comply with this code or equivalent. ATL systems coupled with a solar photovoltaic (PV) or a photovoltaic thermal system (PVT) shall comply with this code or NFPA 70, or equivalent. These systems shall optimize the use of the equipment and energy based on the system design intent.

717.1.1 System Performance. The System Coefficient of Performance (SCOP) shall account for the net COP of each individual component(s) in the district. The SCOP shall be provided by the designer and included in the system design documents.

717.1.2 Emergency Response. An auxiliary heating or cooling methodology shall be provided with the ATL controls and shall be adequate to provide temporary service in the absence of an ATL energy transfer. Emergency source/sink measures such as, but not limited to, control subroutines that move energy between spaces in the building, the use of locally connected ground-source assets, combined heat and power (CHP), conventional equipment, and other renewable systems shall be permitted to be used.

717.2 District Load Profiles. The district load profile of an ambient temperature loop (ATL) distributed energy system shall be identified and shall be included in the basis-of-design (BOD).

717.2.1 System Asset Identification. System assets shall be listed and included in the system design. The system assets shall include, but not be limited to, the following:

1. Building type and quantity.
2. Natural or constructed sources and sinks such as ground water, boreholes, etc.
3. Other renewable assets.
5. Potable and non-potable water or fluid sources.
6. Conventional assets such as boilers and cooling towers.
7. Other geothermal micro-districts or thermal highways.

717.2.2 Driver Building. The driver building profile shall be identified in an ATL distributed energy system and shall be reported in the design documents.

717.2.3 Diversity Factor. The diversity factor and/or anticipated wasted energy recovery component of the geothermal micro-district shall be identified by the designer, and this information shall be included in the drawings and specifications.
CHAPTER 8
SOLAR PHOTOVOLTAIC SYSTEMS

Part I – General.

801.0 General.

801.1 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.

801.2 Applicability. This chapter applies to solar PV systems, other than those covered by Section 830.0 Part IX of this chapter, including the array circuit(s), inverter(s), and controller(s) for such systems. (See Figure 801.2(1) and Figure 801.2(2)). The systems covered by this chapter include those interactive with other electric power production sources or stand-alone, or both. These PV systems may have ac or dc output for utilization. ([NFPA 70:690.1])

802.0 General Requirements.

802.1 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)])

802.2 Equipment. Inverters, electronic power converters, motor generators, PV modules, ac modules and ac module systems, dc combiners, dc to dc converters, PV rapid shutdown equipment (PVRSE), PV hazard control equipment (PVHCE), PV hazard control systems (PVHCS), dc circuit controllers, and charge controllers intended for use in PV systems shall be listed or be evaluated for the application and have a field label applied. ([NFPA 70:690.4(B)])

802.2.1 Listing Requirements. Equipment used in PV power systems shall be listed or field labeled in accordance with Table 802.2.1. Equipment shall be installed in accordance with its listing and the manufacturer’s installation instructions.

802.3 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])

802.4 Multiple PV Systems. Multiple PV systems shall be permitted to be installed in or on a single building or structure. Where the PV systems are remotely located from each other, a directory in accordance with Section 821.1 shall be provided at each PV system disconnecting means. ([NFPA 70:690.4(D)])

802.5 Locations Not Permitted. PV system equipment and disconnecting means shall not be installed in bathrooms. ([NFPA 70:690.4(E)])
802.6 Electronic Power Converters Mounted in Not Readily Accessible Locations. Electronic power converters and their associated devices shall be permitted to be mounted on roofs or other areas that are not readily accessible. Disconnecting means shall be installed in accordance with Section 811.1. [NFPA 70:690.4(F)]

802.7 PV Equipment Floating on Bodies of Water. PV equipment floating on or attached to structures floating on bodies of water shall be identified as being suitable for the purpose and shall utilize wiring methods that allow for any expected movement of the equipment. [NFPA 70:690.4(G)]
**803.0 Alternating-Current (ac) Modules and Systems.**

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

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

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**Part II – Circuit Requirements.**

**804.0 Circuit Requirements.**

**804.1 Maximum Voltage.** The maximum voltage of PV system dc circuits shall be the highest voltage between any two conductors of a circuit or any conductor and ground. The maximum voltage shall be used to determine the voltage and voltage to ground of circuits in the application of this chapter and NFPA 70. Maximum voltage shall be used for conductors, cables, equipment, working space, and other applications where voltage limits and ratings are used. PV system dc circuits on or in buildings shall be permitted to have a maximum voltage no greater than 1000 volts. PV system dc circuits on or in one- and two-family dwellings shall be permitted to have a maximum voltage no greater than 600 volts.

Where not located on or in buildings, listed dc PV equipment rated at a maximum voltage no greater than 1500 volts shall not be required to comply with Part II and III of Article 690 of NFPA 70. The maximum voltage of PV system dc circuits shall be the highest voltage between any two conductors of a circuit or any conductor and ground and shall comply with the following:

(1) PV system dc circuits shall not exceed 1000 volts within or originating from arrays located on or attached to buildings and PV system dc circuits inside buildings.

(2) PV system dc circuits shall not exceed 600 volts on or in one- and two-family dwellings.

(3) PV system dc circuits exceeding 1000 volts shall comply with Section 812.7. [NFPA 70:690.7]

**804.1.1 Photovoltaic Source and Output Circuits.** In a PV source circuit or output circuit, the maximum PV system dc voltage for the PV source circuit shall be calculated in accordance with one of the following methods:

(1) The sum of the PV module–rated open-circuit voltage of the series-connected modules in the PV string circuit corrected for the lowest expected ambient temperature using the correction factors provided in Table 804.1.1.

(2) For crystalline and multicrystalline silicon modules, the sum of the PV module–rated open-circuit voltage of the series-connected modules in the PV string circuit corrected for the lowest expected ambient temperature using the correction factors provided in Table 804.1.1.

For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method maximum voltage calculation provided by a licensed professional electrical engineer. [NFPA 70:690.7(A)]

**TABLE 804.1.1 VOLTAGE CORRECTION FACTORS FOR CRYSTALLINE AND MULTICRYSTALLINE SILICON MODULES [NFPA 70: TABLE 690.7(A)]**

<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>
</tr>
<tr>
<td>58 to 50</td>
<td>1.06</td>
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<tr>
<td>49 to 41</td>
<td>1.08</td>
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<tr>
<td>40 to 32</td>
<td>1.10</td>
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<tr>
<td>31 to 23</td>
<td>1.12</td>
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<tr>
<td>22 to 14</td>
<td>1.14</td>
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<td>4 to -4</td>
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<tr>
<td>-23 to -31</td>
<td>1.23</td>
</tr>
<tr>
<td>-32 to -40</td>
<td>1.25</td>
</tr>
</tbody>
</table>

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 PV 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 determined in accordance with the instructions included in the listing or labeling of the dc-to-dc converter. If the instructions do not provide a method to determine the maximum voltage, 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 the instructions do not provide a method to determine the maximum voltage, 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)]

804.2 Bipolar **PV Source and Output Circuits.** For monopole subarrays in bipolar systems, the maximum voltage shall be the highest voltage between the monopole circuit conductors where one conductor of the monopole subarray circuit is connected to the functionally grounded reference. To prevent overvoltage in the event of a ground fault or arc fault, the monopole circuit conductors shall be isolated from ground. [NFPA 70:690.7(C)]

805.0 Circuit Sizing and Current.

805.1 Calculation of Maximum Circuit Current. The maximum current for the specific circuit shall be calculated in accordance with one of the methods in Section 805.1.1 or Section 805.1.2. [NFPA 70:690.8(A)]

805.1.1 Photovoltaic System Circuits. The maximum current shall be calculated in accordance with Section 805.1.1.1 through Section 805.1.1.5. [NFPA 70:690.8(A)(1)]

805.1.1.1 Photovoltaic Source Currents. The maximum current shall be as calculated in either of the following:

1. The maximum current shall be the sum of the short-circuit current ratings of the PV modules connected in parallel multiplied by 125 percent.

2. For PV systems with an inverter generating capacity of 100 kW or greater, a documented and stamped PV system design, using an industry standard method maximum current calculation provided by a licensed professional electrical engineer, shall be permitted. The calculated maximum current value shall be based on the highest 3-hour current average resulting from the simulated local irradiance on the PV array accounting for elevation and orientation. The current value used by this method shall not be less than 70 percent of the value calculated using Section 805.1.1.1(1). [NFPA 70:690.8(A)(1)(a)]

805.1.1.2 Photovoltaic Output Circuit Currents. The maximum current shall be the sum of parallel source circuit maximum currents as calculated in Section 805.1.1.1. [NFPA 70:690.8(A)(1)(b)]

805.1.1.3 **805.1.1.2 PV DC-to-DC Converter Source Circuit Current.** The maximum current shall be the sum of parallel connected dc-to-dc converter continuous output current ratings. [NFPA 70:690.8(A)(1)(eb)]

805.1.1.4 DC-to-DC Converter Output Circuit Current. The maximum current shall be the sum of parallel connected dc-to-dc converter source circuit currents as calculated in Section 805.1.1.3. [NFPA 70:690.8(A)(1)(d)]

805.1.1.5 **805.1.1.3 Inverter Output Circuit Current.** The maximum current shall be the inverter continuous output current rating. [NFPA 70:690.8(A)(1)(ec)]

805.1.2 Circuits Connected to the Input of Electronic Power Converters. Where a circuit is protected with an overcurrent device not exceeding the conductor ampacity, the maximum current shall be permitted to be the rated input current of the electronic power converter input to which it is connected. [NFPA 70:690.8(A)(2)]

805.1.3 Stand-Alone Inverter Input Circuit Current. The maximum input 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)(3)710.12]

805.2 Conductor Ampacity. Circuit conductors shall be sized to carry have an ampacity not less than the larger ampacity calculated in accordance with of Section 805.2.1 or Section 805.2.2. [NFPA 70:690.8(B)]

805.2.1 Before Application of Without Adjustment and Correction Factors. The minimum conductor size with an ampacity not less than the maximum currents calculated in Section 805.1 multiplied by 125 percent without adjustment or correction factors. Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating. [NFPA 70:690.8(B)(1)]

805.2.2 After Application of With Adjustment and Correction Factors. The maximum currents calculated in Section 805.1 with adjustment and correction factors. [NFPA 70:690.8(B)(2)]

805.3 Systems with Multiple Direct-Current Voltages. For a PV power source that has multiple output circuit voltages and employs a common-return conductor, the ampacity of the common-return conductor shall not be less than the sum of the ampere ratings of the overcurrent devices of the individual output circuits. [NFPA 70:690.8(C)]

805.4 Sizing of Module Interconnection Conductors Multiple PV String Circuits. Where an single overcurrent device is used to protect a more than one set of two or more parallel-connected module PV string circuits, the ampacity of each conductor protected by the module interconnection device shall not be less than the sum of the ratings of the single overcurrent device plus 125 percent of the short-circuit current from the other parallel connected modules. following:

1. The rating of the overcurrent device.
2. The sum of the maximum currents as calculated in Section 805.1.1.1 for the other parallel-connected PV string-circuits protected by the overcurrent device. [NFPA 70:690.8(D)]

805.5 Standard Ampere Ratings. Standard ampere ratings shall be in accordance with Section 805.5.1 through Section 805.5.4.
805.5.1 Fuses and Fixed-Trip Circuit Breakers. 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)]

| STANDARD AMPERE RATINGS FOR FUSES AND INVERSE TIME CIRCUIT BREAKERS [NFPA 70:TABLE 240.6(A)] |
|---|---|---|---|---|---|---|---|
| 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
| 125 | 150 | 175 | 200 | 225 | 250 | 275 | 300 | 325 | 350 | 375 | 400 | 425 | 450 | 475 | 500 |
| 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 |

805.5.2 Adjustable-Trip Circuit Breakers. 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)]

805.5.3 Local Restricted Access Adjustable-Trip Circuit Breakers. 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). Restricted access shall be achieved by one of the following methods:

1. Located behind removable and sealable covers over the adjusting means.
2. Located behind bolted equipment enclosure doors.
3. Located behind locked doors accessible only to qualified personnel.
4. Password protected, with password accessible only to qualified personnel. [NFPA 70:240.6(C)]

805.5.4 Remotely Accessible Adjustable-Trip Circuit Breakers. A circuit breaker(s) that can be adjusted remotely to modify the adjusting means shall be permitted to have an ampere rating(s) that is equal to the adjusted current setting (long-time pickup setting). Remote access shall be achieved by one of the following methods:

1. Connected directly through a local nonnetworked interface.
2. Connected through a networked interface complying with one of the following methods:

(a) The circuit breaker and associated software for adjusting the settings are identified as being evaluated for cybersecurity.
(b) A cybersecurity assessment of the network is completed. Documentation of the assessment and certification shall be made available to those authorized to inspect, operate, and maintain the system. [NFPA 70:240.6(D)]

806.0 Overcurrent Protection. 806.1 Circuits and Equipment. PV system dc circuit and inverter output conductors and equipment shall be protected against overcurrent. Circuits sized in accordance with Section 805.1.2 are required to be protected against overcurrent with overcurrent protective devices. Each circuit shall be protected from overcurrent in accordance with Section 806.1.1, Section 806.1.2 or Section 806.1.3. [NFPA 70:690.9(A)]

806.1.1 Circuits Where Overcurrent Protection Is Not Required. Overcurrent protective devices shall not be required where both of the following conditions are met:

1. The conductors have sufficient ampacity for the maximum circuit current.
2. The currents from all sources do not exceed the maximum overcurrent protective device rating specified for the PV module or electronic power converter. [NFPA 70:690.9(A)(1)]

806.1.2 Circuits Where Overcurrent Protection Is Required on One End. A circuit conductor connected at one end to a current-limited supply, where the conductor is rated for the maximum circuit current from that supply, and also connected to sources having an available maximum circuit current greater than the ampacity of the conductor, shall be protected from overcurrent at the point of connection to the higher current source. [NFPA 70:690.9(A)(2)]

806.1.3 Other Circuits. Circuits that do not comply with Section 806.1.1 or Section 806.1.2 shall be protected with one of the following methods:

1. Conductors not greater than 10 feet (3048 mm) in length and not in buildings, protected from overcurrent on one end.
2. Conductors not greater than 10 feet (3048 mm) in length and in buildings, protected from overcurrent on one end and in a raceway or metal clad cable.
3. Conductors protected from overcurrent on both ends.
4. Conductors not installed on or in buildings are permitted to be protected from overcurrent on one end of the circuit where the circuit complies with all of the following conditions:
   (a) The conductors are installed in metal raceways or metal-clad cables, or installed in enclosed metal cable trays, or underground, or where directly entering pad-mounted enclosures.
(b) The conductors for each circuit terminate on one end at a single circuit breaker or a single set of fuses that limit the current to the ampacity of the conductors.

(c) The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located within 10 feet (3048 mm) of conductor length of the disconnecting means.

(d) The disconnecting means for the conductors is installed outside of a building, or at a readily accessible location nearest the point of entrance of the conductors inside of a building, including installations complying with Section 230.6 of NFPA 70. [NFPA 70:690.9(A)(3)]

### 806.2 Overcurrent Device Ratings

Overcurrent devices used in PV system dc source circuits shall be listed for use in PV systems. Electronic devices that are listed to prevent backfeed current in PV system dc circuits shall be permitted to prevent overcurrent of conductors on the PV array side of the device. Overcurrent devices, where required, shall be rated in accordance with one of the following and permitted to be rounded up to the next higher standard size in accordance with Section 806.2.1:

1. Overcurrent devices shall be rated not less than 125 percent of the maximum currents calculated in Section 805.1.

2. An assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be used at 100 percent of its rating. [NFPA 70:690.9(B)]

### 806.2.1 Overcurrent Devices Rated 800 Amperes or Less

The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

1. The conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and-plug-connected portable loads.

2. The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments).

3. The next higher standard rating selected does not exceed 800 amperes.

If the overcurrent protective device is an adjustable trip device installed in accordance with Section 806.2.1(1) through Section 806.2.1(3), it shall be permitted to be set to a value that does not exceed the next higher standard value above the ampacity of the conductors being protected as shown in Table 805.5.1 where restricted access in accordance with Section 805.5.3 is provided. [NFPA 70:240.4(B)]

### 806.2.2 Overcurrent Devices Rated over 800 Amperes

Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device defined in Section 805.5. [NFPA 70:240.4(C)]

### 806.3 Photovoltaic Source and Output System DC Circuits

A single overcurrent protective device, where required, shall be permitted to protect the PV modules, dc-to-dc converters, and conductors of each source circuit or the conductors of each output circuit. Where single overcurrent protective devices are used to protect 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(C)]

### 806.4 Power Transformers

Overcurrent protection for a transformer with a source(s) on each side power transformers shall be provided installed in accordance with Section 450.3 of NFPA 70 by considering first one side of the transformer, as the primary Section 806.4.1.

**Exception:** A power transformer with a current rating on the side connected toward the 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(D)]

### 806.4.1 Installation

The following apply to the installation of transformers:

1. For the purpose of overcurrent protection, the primary side of transformers with sources on each side shall be the side connected to the largest source of available fault current.

2. Transformer secondary conductors shall be protected in accordance with Section 240.21(C) of NFPA 70. [NFPA 70:705.30(F)]

### 807.0 Stand-Alone Systems

#### 807.1 General

The wiring system connected to a stand-alone system shall be installed in accordance with Section 807.2. [NFPA 70:690.10]

#### 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 807.2.5, and Section 807.2.7. [NFPA 70:710.15]

#### 807.2.1 Supply Output

Power supply to premises wiring systems fed by stand-alone or isolated microgrid power sources shall be permitted to have less capacity than the calculated load. The capacity of the sum of all sources of the stand-alone supply shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load. [NFPA 70:710.15(A)]

#### 807.2.2 Sizing and Protection

The circuit conductors between a stand-alone source and a building or struc-
ture disconnecting means shall be sized based on the sum of the output ratings of the stand-alone source(s). For three-phase interconnections, the phase loads shall be controlled or balanced to be compatible with specifications of the sum of the power supply capacities. [NFPA 70:710.15(B)]

**807.2.3 Single 120-Volt Supply.** Stand-alone and isolated microgrid 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 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 810.12. [NFPA 70:710.15(C)]

**807.2.4 Three-phase Supply.** Stand-alone and microgrid systems shall be permitted to supply three-phase, three-wire or four-wire systems. [NFPA 70:710.15(D)]

**807.2.5 Energy Storage or Backup Power System Requirements.** Energy storage or backup power supply shall not be required. [NFPA 70:710.15(E)]

**807.2.6 Backfed Circuit Breakers.** Plug-in type backfed circuit breakers connected to an interconnected supply shall be secured in accordance with Section 807.2.6.1. Circuit breakers marked “line” and “load” shall not be backfed. [NFPA 70:710.15(F)]

**810.17 8072.6 Suitable for Backfeed.** Fused disconnects, unless otherwise marked, shall be considered suitable for backfeed. Circuit breakers not marked “line” and “load” shall be considered suitable for backfeed. Circuit breakers marked “line” and “load” shall be considered suitable for backfeed or reverse current if specifically rated. [NFPA 70:705.4230(D)]

**8072.6.1 Backfed Devices.** Plug-in type overcurrent protection devices or plug-in type main lug assemblies that are backfed 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 panelboard. [NFPA 70:408.36(D)]

**8072.7 Voltage and Frequency Control.** The stand-alone or isolated microgrid system power sources shall be controlled during operation so that voltage and frequency remain within suitable limits for compatible with the connected loads. [NFPA 70:710.15(G(D)]

**808.0 Arc-Fault Circuit Protection (Direct-Current).**

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

**Exception:** For PV systems not installed on or in buildings, PV output circuits and dc-to-dc converter output circuits that utilize metal-clad cables, are installed in metal raceways or metal clad cables, or installed in enclosed metal cable trays, or are underground shall be permitted without arc-fault circuit protection: if the installation complies with at least one of the following:

1. The PV system dc circuits are not installed in or on buildings,
2. The PV system dc circuits are located in or on detached structures whose sole purpose is to house support or contain PV system equipment shall not be considered buildings according to this exception. [NFPA 70:690.11]

**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 to reduce shock hazard for firefighters in accordance with Section 809.1.1 through Section 809.1.4, 809.1.3, and Section 825.2.

**Exceptions:**

1. 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 this section.
2. PV equipment and circuits installed on nonenclosed detached structures including but not limited to parking shade structures, carports, solar trellises, and similar structures shall not be required to comply with this section. [NFPA 70:690.12]

**809.1.1 Controlled Conductors.** Requirements for controlled conductors shall apply to the following:

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

**Exception:** PV system circuits originating within or from arrays not attached to buildings that terminate on the exterior of buildings and PV system circuits installed in accordance with Section 230.6 of NFPA 70 shall not be considered controlled conductors for the purposes of Section 809.1. [NFPA 70:690.12(A)]

**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. Equipment and systems shall be permitted to meet the requirements of both inside and outside the array as defined by the manufacturer’s instructions included with the listing. [NFPA 70:690.12(B)]
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)(1)]

809.1.2.2 Inside the Array Boundary. The PV system shall comply with one of the following:

1. The PV system shall provide shock hazard control system listed for firefighters through the use of a PVHCS installed in accordance with the instructions included with the listing or field labeling. Where a PVHCS requires initiation to transition to a controlled state, the rapid shutdown initiation device required in Section 809.1.3 shall perform this initiation.

2. A connector meeting the requirements of Section 810.1 shall initiate the rapid shutdown function of the PV system.

809.1.3 Initiation Device. The PV system shall initiate the rapid shutdown function of the PV system. The device’s “off” position shall indicate that the rapid shutdown function has been initiated for all PV systems connected to that device. For one-family and two-family dwellings an initiation device(s), where required, shall be located at a readily accessible outdoor location outside the building. For a single PV system, the rapid shutdown initiation shall occur by the operation of any single initiation device(s). Devices that perform the rapid shutdown function shall be listed for providing rapid shutdown protection. [NFPA 70:690.12(D)]

Part III – Disconnecting Means.

810.0 Disconnecting Means.

810.1 Photovoltaic System Disconnecting Means. Means shall be provided to disconnect the PV system from all wiring systems including power systems, energy storage systems, and utilization equipment and its associated premises wiring. [NFPA 70:690.13]

810.1.1 Location. The PV system disconnecting means shall be installed at a readily accessible location. Where a disconnecting means of systems for circuits operating above 30 volts is readily accessible to unqualified persons, e.g., an enclosure door or hinged cover that exposes live energized parts when open shall be have its door or cover locked or require a tool to be opened. [NFPA 70:690.13(A)]

810.1.3 Suitable for Use. If the PV system is connected to the supply side of the service disconnecting means 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 70-2017:690.13(C)]

810.1.4 Maximum Number of Disconnects. 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(C)]

810.1.5 Ratings. The PV system disconnecting means shall have ratings sufficient for the maximum circuit current available fault current, and voltage that is available at the terminals of the PV system disconnect. [NFPA 70:690.13(D)]

810.1.6 Type of Disconnect. The PV system disconnecting means shall simultaneously disconnect the PV system conductors that are not solidly grounded from all conductors of other wiring systems. The PV system disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with Section 810.1.6.1. The PV system disconnecting means shall be one of the following:

1. A manually operable switch or circuit breaker.
2. A connector meeting the requirements of Section 814.1.4(1) or Section 814.1.4(3).
(3) A pull-out switch with the required interrupting rating.

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

(5) A device listed or approved for the intended application. [NFPA 70:690.13(E)]

**810.1.4.1 Lockable Disconnecting Means.** If a disconnecting means is required to be lockable open elsewhere in this chapter, it shall be capable of being locked in the open position. The provisions for locking shall remain in place with or without the lock installed.

**Exception:** Locking provisions for a cord-and-plug connection shall not be required to remain in place without the lock installed. [NFPA 70:110.25]

### 811.0 Disconnection of Disconnecting Means for Isolating Photovoltaic Equipment

#### 811.1 Isolating Devices General

Disconnecting means of the type required in Section 811.4 811.1.1 shall be provided to disconnect ac PV modules, fuses, dc-to-dc converters, inverters, and charge controllers from all conductors that are not solidly grounded. [NFPA 70:690.15]

#### 811.1.4 811.1.1 Type of Disconnecting Means. Where disconnects are a disconnect is required to isolate equipment, the disconnecting means shall be one of the following applicable types:

1. An equipment disconnecting means in accordance with Section 811.1.3 shall be required to isolate dc circuits with a maximum circuit current over 30 amperes.

2. An isolating device in accordance with Section 811.1.2 shall be permitted for circuits other than those covered by Section 811.1.4(1). An isolating device as part of listed equipment where an interlock or similar means prevents the opening of the isolating device under load.

3. For circuits with a maximum circuit current of 30 amperes or less, an isolating device in accordance with Section 811.1.2. [NFPA 70:690.15(DΔ)]

#### 811.1.2 Isolating Device

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

1. A mating connector meeting the requirements of Section 814.1 and listed and identified for use with specific equipment.

2. A finger-safe fuse holder.

3. An isolating device that requires a tool to place the device in the open (off) position.

4. An isolating device listed for the intended application. [NFPA 70:690.15(B)]

### 811.1.3 Equipment Disconnecting Means. Equipment disconnecting means shall comply with the following:

1. Have ratings sufficient for the maximum circuit current, available fault current, and voltage that is available at the terminals. Equipment disconnecting means shall

2. Simultaneously disconnect all current-carrying conductors that are not solidly grounded to the circuit to which it is connected. Equipment disconnecting means shall

3. Be externally operable without exposing the operator to contact with energized parts and shall indicate whether in the open (off) or closed (on) position. Where not within sight or not within 10 feet (3048 mm) of the equipment, the disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means shall be capable of being locked in accordance with Section 810.1.6.1 through Section 810.1.6(5) 810.1.4(5). Equipment disconnecting means, other than those complying with Section 814.1, shall be marked in accordance with the warning in Section 810.1.2 823.1 if the line and load terminals can be energized in the open position. [NFPA 70:690.15(C)]

#### 811.1.4 Location and Control

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. Where disconnecting means of equipment operating above 20 volts are readily accessible to unqualified persons, any enclosure door or hinged cover that exposes live parts when open shall be locked or require a tool to open comply with one or more of the following:

1. Located within the equipment

2. Located in sight from and readily accessible from the equipment for those to whom access is required

3. Lockable in accordance with Section 810.1.4.1

4. Provided with remote controls to activate the disconnecting means where the remote controls comply with one of the following:
   
   a. The disconnecting means and their controls are located within the same equipment.

   b. The disconnecting means is lockable in accordance with Section 810.1.4.1, and the location of the controls are marked on the disconnecting means. [NFPA 70:690.15(AD)]
Part IV – Wiring Methods.

812.0 Wiring Methods Permitted.

812.1 Wiring Systems. Wiring systems shall be in accordance with Section 812.1.1 through Section 812.1.4. All raceway and cable wiring methods included in NFPA 70, other wiring systems and fittings specifically listed for use in PV arrays, and wiring as part of a listed system shall be permitted.

812.1.1 Serviceability. Where wiring devices with integral enclosures are used, sufficient length of cable shall be provided to facilitate replacement. [NFPA 70:690.31(A)(1)]

812.1.2 Where Readily Accessible. Where not guarded, PV source and output circuits system dc circuit conductors operating at voltages greater than 30 volts that are installed in readily accessible locations, circuit conductors to unqualified persons shall be guarded or installed in Type MC cable, in multiconductor jacketed cable, or in raceway. [NFPA 70:690.31(A)(2)]

812.1.3 Conductor Ampacity. The ampacity of 221°F (105°C) and 257°F (125°C) conductors shall be permitted to be determined by Table 812.1(2) 812.1.3(1). For ambient temperatures greater than 86°F (30°C), the ampacities of these conductors shall be corrected in accordance with Table 812.1(2) 812.1.3(2). [NFPA 70:690.31(A)(3)]

812.1.4 Special Equipment. In addition to wiring methods included elsewhere in this chapter, other wiring systems specifically listed for use in PV systems shall be permitted. [NFPA 70:690.31(A)(4)]

TABLE 812.1(1) 812.1.3(1)
AMPACITIES OF INSULATED CONDUCTORS RATED UP TO AND INCLUDING 2000 VOLTS\(^1,2,3\)
[NFPA 70: TABLE 690.31(A)(6)(3)(1)]

<table>
<thead>
<tr>
<th>AWG</th>
<th>PVC, CPE, XLPE 221°F (AMPERES)</th>
<th>XLPE, EPDM 257°F (AMPERES)</th>
</tr>
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<tbody>
<tr>
<td>18</td>
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<td>263</td>
<td>284</td>
</tr>
<tr>
<td>4/0</td>
<td>301</td>
<td>325</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8

Notes:

1 Not more than three current-carrying conductors in raceway, cable, or earth (directly buried).
2 Based on ambient temperature of 86°F (30°C).
3 For temperatures 221°F (105°C) through 257°F (125°C).
4 See Section 110.14(C) of NFPA 70 for conductor temperature limitations due to termination provisions.

812.2 Identification and Grouping. PV system dc circuits and Class I remote control, signaling, and power limited circuits of a PV system shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway, as other non-PV systems, or inverter output circuits, unless the PV system dc circuits are separated from other circuits by a barrier or partition. PV system circuit conductors shall be identified and grouped as required by Section 812.2.1 through Section 812.2.3. Exception: PV system dc circuits utilizing multiconductor jacketed cable or metal clad cable assemblies or listed wiring harnesses identified for the application shall be permitted to occupy the same wiring method as inverter output circuits and other non-PV systems. All conductors, harnesses, or assemblies shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway. [NFPA 70:690.31(B)]

812.2.1 Conductors of Different Systems. Where not otherwise allowed in an equipment’s listing, PV system dc circuits shall not occupy the same equipment wiring enclosure, cable, or raceway as other non-PV systems or inverter output circuits unless separated from other circuits by a barrier or partition. Exception: Where all conductors or cables have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the same wiring method, the following shall be permitted:
Multiconductor jacketed cables for remote control, signaling, or power-limited circuits shall be permitted within the same wiring enclosure, cable, or raceway as PV system dc circuits where all circuits serve the PV system.

Inverter output circuits shall be permitted to occupy the same junction box, pull box, or wireway with PV system dc circuits that are identified and grouped as required by Section 812.2.2 and Section 812.2.3.

PV system dc circuits utilizing multiconductor jacketed cable or metal-clad cable assemblies or listed wiring harnesses identified for the application shall be permitted to occupy the same wiring method as inverter output circuits and other non-PV systems. [NFPA 70:690.31(B)(1)]

**812.2.1 812.2.2 Identification.** PV system dc circuit conductors shall be identified at all termination, connection, and splice points by color coding, marking tape, tagging, or other approved means. [NFPA 70:690.31(C)(1)]

Conductors that rely on other than color coding for polarity identification shall be identified by an approved permanent marking means such as labeling, sleeving, or shrink-tubing that is suitable for the conductor size.

The permanent marking means for nonsolidly grounded positive conductors shall include imprinted plus signs (+) or the word POSITIVE or POS durably marked on insulation of a color other than green, white, or gray. The permanent marking means for nonsolidly grounded negative conductors shall include imprinted negative signs (−) or the word NEGATIVE or NEG durably marked on insulation of a color other than green, white, gray, or red. Only solidly grounded PV system dc circuit conductors shall be marked in accordance with Section 200.6 of NFPA 70.

*Exception:* Where the identification of the conductors is evident by spacing or arrangement, further identification shall not be required. [NFPA 70:690.31(B)(2)]

**812.2.3 Grouping.** Conductors of more than one PV system occupy the same junction box, pull box, or wireway with a removable cover(s) wireway, the PV system ac and dc circuit conductors of each system shall be grouped separately by cable ties or similar means at least once and shall then be grouped at intervals not to exceed 6 feet (1829 mm). [NFPA 70:690.31(B)(3)]

*Exception:* The requirement for grouping shall not apply if the circuit enters from a cable or raceway unique to the circuit that makes the grouping obvious. [NFPA 70:690.31(B)(4)]

**812.3 Cables.** Type PV wire or cable and Type distributed generation (DG) cable shall be listed. [NFPA 70:690.31(C)]

**812.3 812.3.1 Single-Conductor Cable.** Single-conductor cables shall comply with the following:

1. Single-conductor cable in exposed outdoor locations in PV system dc circuits within the PV array shall be permitted to be one of the following:
   1. PV wire or cable.
   2. Single-conductor cable marked sunlight resistant and Type USE-2 and Type RH-2.

2. Exposed cables sized 8 AWG or smaller shall be supported and secured at intervals not to exceed 2 feet (610 mm) by cable ties, straps, hangers, or similar fittings listed and identified for securing and support in outdoor locations. PV wire or cable shall be permitted in all locations where RHW-2 is permitted.

*Exception:* PV systems meeting the requirements of Section 820.3 830.2 shall be permitted to have support and securing intervals as defined in the engineered design. [NFPA 70:690.31(C)(1)]

3. Exposed cables sized larger than 8 AWG shall be supported and secured at intervals not to exceed 54 inches (1372 mm) by cable ties, straps, hangers, or similar fittings listed and identified for securing and support in outdoor locations. [NFPA 70:690.31(C)(2)]

**812.4 812.3.3 Multiconductor Jacketed Cables.** Conductors PV wire or cable of all sizes or distributed generation (DG) cable of all sizes, with or without a cable tray rating, shall be permitted in cable trays installed in outdoor locations, provided that the cables are supported at intervals not to exceed 12 inches (305 mm) and secured at intervals not to exceed 4 ½ feet (1372 mm). Where installed in uncovered cable trays, ampacity of single-conductor PV wire smaller than 1/0 AWG, the adjustment factors for 1/0 AWG single-conductor cable in Section 392.80(A)(2) of NFPA 70 shall be permitted to be used. Where single-conductor PV wire smaller than 1/0 AWG is installed in ladder ventilated trough cable trays, the following shall apply:

1. All single conductors shall be installed in a single layer.

2. Conductors that are bound together to comprise each circuit pair shall be permitted to be installed in other than a single layer.

3. The sum of diameters of all single conductor cables shall not exceed the cable tray width. [NFPA 70:690.31(C)(2)]

**812.4 812.3.3 Multiconductor Jacketed Cables.** Where part of a listed PV assembly, multiconductor jacketed cables shall be installed in accordance with the included instructions. Where not part of a listed assembly, or where not otherwise covered in this chapter or NFPA 70, multiconductor jacketed cables, including DG cable, shall be installed in accordance with the product listing and shall be permitted in PV systems. These cables shall be installed in accordance with the following:

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

2. Where not in raceways, in accordance with the following:
(a) Marked sunlight resistant in exposed outdoor locations.
(b) Protected or guarded, where subject to physical damage.
(c) Closely follow the surface of support structures.
(d) Secured at intervals not exceeding 6 feet (1829 mm).
(e) Secured within 2 feet (610 mm) of mating connectors or entering enclosures.
(f) Marked direct burial, where buried in the earth. [NFPA 70:690.31(C)(3)]

**812.6 812.3.4 Flexible Cords and Cables.** Flexible cords and flexible cables, where connected to moving parts of tracking PV arrays, shall comply with Article 400 of NFPA 70 and shall be of a type identified as a hard service cord or portable power cable; they shall be suitable for extra-hard usage, listed for outdoor use, water resistant, and sunlight resistant. Allowable ampacities shall be in accordance with Section 400.5 of NFPA 70. Stranded copper PV wire shall be permitted to be connected to moving parts of tracking PV arrays in accordance with the minimum number of strands specified in Table 812.5 812.3.4. [NFPA 70:690.31(C)(4)]

<table>
<thead>
<tr>
<th>PV WIRE AWG</th>
<th>MINIMUM STRANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>17</td>
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<tr>
<td>16 – 10</td>
<td>19</td>
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<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>

**812.6 812.3.5 Flexible, Fine-Stranded Cables.** 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(C)(5)]

**812.6 812.3.6 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 meet the ampacity requirements of Section 400.5 of NFPA 70. Section 310.14 of NFPA 70 shall be used to determine the cable ampacity adjustment and correction factors. [NFPA 70:690.31(C)(6)]

**812.7 812.4.4 Photovoltaic System Direct-Current Circuits on or in a Building.** Where inside buildings, PV system dc circuits that exceed 30 volts or 8 amperes shall be contained in metal raceways. Rigid metal conduit in the same effective ground-fault current designator 21 or Type MC metal-clad cable with branches smaller than 1 inch (25 mm) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 6 feet (1829 mm) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means. [NFPA 70:690.31(D)(1)]

**812.7.1 Flexible Wiring Methods.** Where flexible metal conduit (FMC) smaller than the trade size 1⁄4 (35 metric designator 21) or Type MC cable smaller than 1 inch (25 mm) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable. Where run exposed, other than within 6 feet (1829 mm) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means. [NFPA 70:690.31(D)(1)]

**812.4.1 Metal Raceways and Enclosures.** Where inside buildings, PV system dc circuits that exceed 30 volts or 8 amperes shall be contained in metal raceways. In Type MC metal-clad cable that complies with Section 812.4.2(10)(b), or in metal enclosures. Exception: PVHCS installed in accordance with Section 809.1.2.2(1) shall be permitted to be provided with or listed for use with nonmetallic enclosure(s), nonmetallic raceway(s), and cables other than Type MC metal-clad cable(s), at the point of penetration of the surface of the building. [NFPA 70:690.31(D)(1)]

**812.7.3 812.4.2 Types of Equipment Grounding Conductors.** The Each equipment grounding conductor run 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 1⁄4 (35 metric designator).
   d. The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 6 feet (1829 mm).
   e. If used to connect equipment where flexibility is necessary to minimize the transmission of...
vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with Section 812.4.2.1 shall be installed.

(f) If flexible metal conduit is constructed of stainless steel, a wire-type equipment grounding conductor or bonding jumper in accordance with Section 812.4.2.1 shall be installed.

(6) Listed liquidtight flexible metal conduit meeting all the following conditions:

(a) The conduit is terminated in listed fittings.

(b) For trade sizes 1⁄8 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 3⁄4 through 1 1⁄2 (12 through 16 metric designator) in the effective ground-fault current path.

(d) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 6 feet (1829 mm).

(e) If used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, a wire-type equipment grounding conductor or a bonding jumper in accordance with Section 812.4.2.1 shall be installed.

(f) If liquidtight flexible metal conduit contains a stainless steel core, a wire-type equipment grounding conductor or a bonding jumper in accordance with Section 812.4.2.1 shall be installed.

(7) Flexible metallic tubing where if the tubing is terminated in listed fittings and meeting the following conditions:

(a) The circuit conductors contained in the tubing are protected by overcurrent devices rated at 20 amperes or less.

(b) The combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the same effective ground-fault current path does not exceed 6 feet (1829 mm).

(8) Armor of Type AC cable as provided in Section 320.108 of NFPA 70.

(9) The copper sheath of mineral-insulated, metal-sheathed cable Type MI.

(10) 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 compliance with Section 812.7.3(1)(a) 812.4.2(1).

(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.

(11) Cable trays as permitted in Section 392.10 of NFPA 70 and Section 392.60 of NFPA 70.

(12) Cablebus framework as permitted in Section 370.60(1) of NFPA 70.

(13) Other listed electrically continuous metal raceways and listed auxiliary gutters.

(14) Surface metal raceways listed for grounding. [NFPA 70:250.118(A)]

812.4.2.1 Outside a Raceway or an Enclosure. If installed on the outside, the length of the bonding jumper or conductor or equipment bonding jumper shall not exceed 6 feet (1829 mm) and shall be routed with the raceway or enclosure.

Exception: An equipment bonding jumper or supply-side bonding jumper longer than 6 feet (1829 mm) shall be permitted at outside pole locations for the purpose of bonding or grounding isolated sections of metal raceways or elbows installed in exposed risers of metal conduit or other metal raceway, and for bonding grounding electrodes, and shall not be required to be routed with a raceway or enclosure. [NFPA 70:250.102(E)(2)]

812.9 812.5 Bipolar PV Systems. Where the sum, without consideration of polarity, of the voltages of the two monopole circuits exceeds the rating of the conductors and connected equipment, monopole circuits in a bipolar PV system shall be physically separated, and the electrical output circuits from each monopole circuit shall be installed in separate raceways until connected to the inverter. The disconnecting means and overcurrent protective devices for each monopole circuit output shall be in separate enclosures. All conductors from each separate monopole circuit shall be routed in the same raceway. Solidly grounded bipolar PV systems shall be clearly marked with a permanent, legible warning notice indicating that the disconnection of the grounded conductor(s) may result in overvoltage on the equipment.

Exception: Listed switchgear rated for the maximum voltage between circuits and containing a physical barrier separating the disconnecting means for each monopole circuit shall be permitted to be used instead of disconnecting means in separate enclosures. [NFPA 70:690.31(E)]
812.6 Wiring Methods and Mounting Systems. Rooftop-mounted PV array mounting systems shall be permitted to be held in place with an approved means other than those required by Section 110.13 of NFPA 70 and shall utilize wiring methods that allow any expected movement of the array. [NFPA 70:690.31(F)]

812.7 Over 1000 Volts DC. Equipment and wiring methods containing PV system dc circuits with a maximum voltage greater than 1000 volts shall comply with the following:

1. Shall not be permitted on or in one- and two-family dwellings.
2. Shall not be permitted within buildings containing habitable rooms.
3. Where installed on the exterior of buildings shall be located less than 10 feet (3048 mm) above grade. Wiring methods containing PV system dc circuits connected to this equipment shall not be permitted to attach to the building greater than 33 feet (10 058 mm) along the building surface from the equipment. [NFPA 70:690.31(G)]

813.0 Component Interconnections.

813.1 Concealed Fittings and Connectors. Fittings and connectors that are intended to be concealed at the time of on-site assembly, where listed for such use, shall be permitted for on-site interconnection of modules or other array components. Such fittings and connectors shall be equal to the wiring method employed in insulation, temperature rise, and short-circuit current rating, and shall be capable of resisting the effects of the environment in which they are used. [NFPA 70:690.32]

814.0 Connectors.

814.1 General. Mating connectors, other than connectors covered by Section 813.1, shall comply with Section 814.1.1 through Section 814.1.4. [NFPA 70:690.33]

814.1.1 Configuration. The mating connectors shall be polarized and shall have a configuration that is non-interchangeable with receptacles in other electrical systems on the premises. [NFPA 70:690.33(A)]

814.1.2 Guarding. The mating connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons. [NFPA 70:690.33(B)]

814.1.3 Type. The mating connectors shall be of the latching or locking type. Mating connectors that are readily accessible and that are used in circuits operating at over 30 volts dc or 15 volts ac shall require a tool for opening. Where mating connectors are not of the identical type and brand, they shall be listed and identified for intermateability, as described in the manufacturer’s instructions. [NFPA 70:690.33(C)]

814.1.4 Interruption of Circuit. Mating connectors shall be one of the following:

1. Rated for interrupting current without hazard to the operator.
2. A type that requires the use of a tool to open and marked “Do Not Disconnect Under Load” or “Not for Current Interrupting.”

(3) Supplied as part of listed equipment and used in accordance with instructions provided with the listed connected equipment. [NFPA 70:690.33(D)]

815.0 Access to Boxes.

815.1 Junction, Pull, and Outlet Boxes. Junction, pull, and outlet boxes located behind modules or panels shall be so installed that the wiring contained in them can be rendered accessible directly or by displacement of a module(s) or panel(s) secured by removable fasteners and connected by a flexible wiring system. [NFPA 70:690.34]

Part V – Grounding and Bonding.

816.0 Grounding and Bonding.

816.1 PV System DC Circuit Grounding Configurations. One or more of the following system configurations shall be employed for PV system dc circuits:

1. 2-wire PV arrays circuits with one functionally grounded conductor.
2. Bipolar PV arrays circuits 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 circuits.
5. Solidly grounded PV arrays circuits as permitted in Section 816.2.
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 Circuits protected by equipment listed and identified for the use. [NFPA 70:690.41(A)]

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)]

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)]

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)]

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)]
816.1.5 Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material 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 DC Ground-Fault Detector-Interrupter (GFDI) Protection. PV system dc circuits that exceed 30 volts or 8 amperes shall be provided with dc ground fault GFDI protection meeting the requirements of Section 816.3 and Section 816.2.2 to reduce fire hazards.

816.3 Ground-Fault Detection. The ground-fault protection GFDI device or system shall detect ground fault(s) in the PV system dc circuit, including any functionally grounded conductors, and be listed for providing PV-ground fault GFDI protection.

For dc-to-dc converters not listed as providing ground-fault GFDI protection, where required, the ground-fault protection equipment identified for the combination of the dc-to-dc converter and ground-fault protection [NFPA 70:690.41(B)] the GFDI device shall be installed to protect the circuit. [NFPA 70:690.41(B)(1)]

816.4 Isolating Faulted Circuits. The faulted circuits shall be controlled by one of the following methods:

(1) The current-carrying conductors of the faulted circuit shall be automatically disconnected.

(2) The device providing ground-fault GFDI protection fed by the faulted circuit shall automatically cease to supply power to output circuits and interrupt the faulted PV system dc circuits from the ground reference in a functionally grounded system. [NFPA 70:690.41(B)(2)]

816.2.3 Indication of Faults. The GFDI protection equipment shall provide indication of ground faults at a readily accessible location. [NFPA 70:690.41(B)(3)]

817.0 Point of PV System DC Circuit Grounding Connection.

817.1 Circuits with GFDI Protection Grounding Connection. Systems with a ground-fault protective device Circuits protected by GFDI equipment in accordance with Section 816.2 shall have any current-carrying conductor circuit-to-ground connection made by the ground-fault protective device GFDI equipment. [NFPA 70:690.42(A)]

817.2 Solidly Grounded Circuits. For solidly grounded PV systems dc circuits, the dc output grounding connection shall be made at any single point on the PV output circuit to a point in the grounding electrode system in Section 820.2. [NFPA 70:690.42(B)]

818.0 Equipment Grounding and Bonding. 818.1 General. Exposed non-current-carrying metal parts of PV module frames, electrical equipment, and conductor enclosures of PV systems shall be connected to an equipment grounding conductor in accordance with Section 818.1.3 or Section 250.136 of NFPA 70, regardless of voltage. Equipment grounding conductors and devices shall comply with Section 818.1.1 through Section 818.1.4. [NFPA 70:690.43]

818.1.1 Photovoltaic Mounting Systems and Devices. Devices and systems used for mounting PV modules that are also used for bonding module frames shall be listed, labeled, and identified for bonding PV modules. Devices that mount adjacent PV modules shall be permitted to bond adjacent PV modules. [NFPA 70:690.43(C)]

818.1.2 Equipment Secured to Grounded Metal Supports. Devices listed, labeled, and identified for bonding and grounding the metal parts of PV systems shall be permitted to bond the equipment to grounded metal supports. Metallic support structures shall have identified bonding jumpers connected between separate metallic sections or shall be identified for equipment bonding and shall be connected to the equipment grounding conductor. [NFPA 70:690.43(B)]

818.1.3 With Circuit Conductors Location. Equipment grounding conductors for the PV array and support structure where installed shall be contained within the same raceway or cable or otherwise permitted to be run with separately from the PV system conductors where those within the PV array. Where PV system circuit conductors leave the vicinity of the PV array, equipment grounding conductors shall comply with Section 818.1.3.1. [NFPA 70:690.43(C)]

818.2 Equipment Fastened in Place or Connected by Permanent Wiring Methods (Fixed) — Grounding. Unless connected 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, if grounded, shall be connected to an equipment grounding conductor by one of the following methods:

(1) By connecting to any of the equipment grounding conductors permitted by Section 812.7.3(2) 812.4.2(2) through Section 812.7.3(14) 812.4.2(14).

Exception: As provided in Section 250.130(C) of NFPA 70, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

(2) By connecting to an equipment grounding conductor of the wire type that is contained within the same raceway, contained within the same cable, or otherwise run with the circuit conductors.
Exceptions:

(1) As provided in Article 250.130(C) of NFPA 70, 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 70:250.134]

818.1.4 Bonding for Over 250 Volts. The bonding requirements contained in Section 250.97 of NFPA 70 shall apply only to solidly grounded PV system circuits operating over 250 volts to ground. [NFPA 70:690.43(D)]

819.0 Size of Equipment Grounding Conductors.

819.1 General. Equipment grounding conductors for PV system 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 in accordance with Section 806.2 shall be used when applying Table 819.1. Increases in equipment grounding conductor size to address voltage drop considerations shall not be required. [NFPA 70:690.45]

819.1.1 819.2 Equipment Grounding Conductor Installation. An equipment grounding conductor shall be installed in accordance with Section 819.1.2 819.2.1, Section 819.1.3 819.2.2, and Section 819.1.4 819.2.3. [NFPA 70:250.120]

819.1.2 819.2.1 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 if 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 of raceway or cable used. All connections, joints, and fittings shall be made tight using suitable tools. [NFPA 70:250.120(A)]

819.1.3 819.2.2 Aluminum and Copper-Clad Aluminum Conductors. Equipment grounding conductors of bare, covered, or insulated aluminum or copper-clad aluminum shall comply with the following:

(1) Unless part of a suitable cable wiring method in accordance with Chapter 3 of NFPA 70, bare or covered conductors shall not be installed where subject to corrosive conditions or be installed in direct contact with concrete, masonry, or the earth.

(2) Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 18 inches (457 mm) of the bottom of the enclosure.

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Notes:

1 Where necessary to comply with Section 816.1.5 of this chapter or Section 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 819.1.1 819.2.
(3) Aluminum or copper-clad aluminum conductors external to buildings or enclosures shall not be terminated within 18 inches (457 mm) of the earth, unless terminated within a listed wire connector system. [NFPA 70:250.120(B)]

819.4.4 819.2.3 Equipment Grounding Conductors Smaller Than 6 AWG. Where not routed with circuit conductors as permitted in Article 250.130(C) of NFPA 70 and Section 818.2(1) and Section 818.1.3.1(2), equipment grounding conductors smaller 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)]

820.0 Grounding Electrode System.
820.1 Electrode System. All grounding electrodes as described in Section 820.1.1 through Section 820.1.7 that are present at each building or structure served shall be bonded together to form the grounding electrode system. Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in Section 820.1.4 through Section 820.1.8 shall be installed and used.

Exception: Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcing bars, or rebar, if the rebar is not accessible for use without disturbing the concrete. [NFPA 70:250.50]

Grounding of electrode systems shall comply with Section 820.2 and Section 820.3.

820.1.1 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), if installed. [NFPA 70:250.52(A)(1)]

820.1.2 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)]

820.1.3 Concrete-Encased Electrode. A concrete-encased electrode shall consist of at least 20 feet (6096 mm) of either of the following:

1. One or more bare or hot galvanized or other electrically conductive coated steel reinforcing bars or rebar of not less than ½ of an inch (12.7 mm) in diameter, installed in one continuous 20 foot (6096 mm) length, or if in multiple pieces, the rebar shall be connected together by the usual steel tie wires, exothermic welding, welding, or other effective means to create a 20 foot (6096 mm) or greater length.

2. Bare copper conductor not smaller than 4 AWG. Metallic components shall be encased by 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. 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. [NFPA 70:250.52(A)(3)]

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

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

1. Grounding electrodes of pipe or conduit shall not be smaller than trade size ¼ (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 at least ⅝ of an inch (15.9 mm) in diameter, unless listed. [NFPA 70:250.52(A)(5)]

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

820.1.7 Plate Electrodes. Each plate electrode shall expose not less than 2 square feet (0.2 m²) of surface to exterior soil. Electrodes of bare or electrically conductive coated iron or steel plates shall be at least ¼ of an inch (6.4 mm) in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least 0.06 of an inch (1.52 mm) in thickness. [NFPA 70:250.52(A)(7)]

820.1.8 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)]

820.1.9 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) and Section 680.26(B)(2) of NFPA 70. [NFPA 70:250.52(B)]

820.2 Buildings or Structures Supporting a PV Array. A building or structure(s) supporting a PV system shall utilize...
a grounding electrode system installed in accordance with Part III of Article 250 of NFPA 70 \[Section 820.3.\]

PV array equipment grounding conductors shall be connected to a grounding electrode system 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 specific PV system grounding configurations permitted in Section 816.1, one of the following conditions shall apply:

(1) For PV systems that are not solidly grounded, the equipment grounding conductor for the output of the PV system, where connected to associated distribution equipment connected to a grounding electrode system, shall be permitted to be the only connection to ground for the system.

(2) 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 820.2.1. \[NFPA 70:690.47(A)\]

820.2.1 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 820.2.2 and Section 820.2.3, except as permitted by Section 820.2.4 through Section 820.2.6. The grounding electrode conductor for a dc system shall meet the sizing requirements in this section but shall not be required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum. \[NFPA 70:250.166\]

820.2.2 Not Smaller Than the Neutral Conductor. Where the dc system consists of a three-wire balancer set or a balancer winding with overcurrent protection as provided in Section 445.12(D) of NFPA 70, the grounding electrode conductor shall not be smaller than the neutral conductor and not smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum. \[NFPA 70:250.166(A)\]

820.2.3 Not Smaller Than the Largest Conductor. Where the dc system is other than as in Section 820.2.2, the grounding electrode conductor shall not be smaller than the largest conductor supplied by the system and not smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum. \[NFPA 70:250.166(B)\]

820.2.4 Connected to Rod, Pipe, or Plate Electrodes. Where connected to rod, pipe, or plate electrodes as in Section 820.1.5 or 820.1.7, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum or copper-clad aluminum wire. \[NFPA 70:250.166(C)\]

820.2.5 Connected to a Concrete-Encased Electrode. Where connected to a concrete-encased electrode as in Section 820.1.3, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than 4 AWG copper wire. \[NFPA 70:250.166(D)\]

820.2.6 Connected to a Ground Ring. Where connected to a ground ring as in Section 820.1.4, that portion of the grounding electrode conductor that is the sole connection to the grounding electrode shall not be required to be larger than the conductor used for the ground ring. \[NFPA 70:250.166(E)\]

820.3 Additional Auxiliary Electrodes for Array Grounding Grounding Electrodes and Grounding Electrode Conductors. Additional grounding electrodes shall be permitted to be installed in accordance with Section 250.54 of NFPA 70, and Section 820.1.1 through Section 820.1.9 of this chapter. Grounding electrodes shall be permitted to be connected directly to the PV module frame(s) or support structure. A grounding electrode conductor shall be sized according to Section 250.66 of NFPA 70. A support structure for a ground-mounted PV array shall be permitted to be considered a grounding electrode if it meets the requirements of Section 820.1.1 through Section 820.1.9. PV arrays mounted to buildings shall be permitted to use the metal structural frame of the building if the requirements of Section 250.68(C)(2) of NFPA 70 are met. \[NFPA 70:690.47(B)\]

Part VI – Marking.

821.0 Marking.

821.1 Directory Identification of Power Sources. A permanent plaque or directory Permanent plaques, labels, or directories shall be installed at each service equipment location, or at an approved readily visible location. The plaque or directory shall in accordance with the following:

(1) Denote the location of each power source disconnecting means for the building or structure and be grouped with other plaques or directories for other on-site sources. The plaque or directory shall be marked with the wording “CAUTION: MULTIPLE SOURCES OF POWER.”

Any posted diagrams shall be correctly oriented with respect to the diagram’s location. The marking shall comply with Section 810.1.2.1.

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

(2) Indicate the emergency telephone numbers of any off-site entities servicing the power source systems.

(3) Be marked with the wording “CAUTION: MULTIPLE SOURCES OF POWER.” The marking shall comply with Section 821.2. \[NFPA 70:705.10\]

810.1.2.1 821.2 Field-Applied Hazard Markings. Where caution, warning, or danger signs or hazard markings such as labels or signs are required by this chapter, the labels markings shall meet the following requirements:

(1) The marking shall be of sufficient durability to withstand the environment involved and warn of the hazards using effective words, colors, symbols, or any combination thereof.
(2) The label marking shall be permanently affixed to the equipment or wiring method and shall not be handwritten.

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

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

821.2 Modules. Modules and ac modules shall be marked in accordance with their listing. [NFPA 70:690.51]

821.3 Format. The marking requirements in Section 810.1.2 and 821.2 shall be provided in accordance with the following:

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

822.0 Marking Direct-Current Photovoltaic Power Source Circuits.

822.1 Labeling. A permanent readily visible label indicating the highest maximum dc voltage in a pv system, calculated in accordance with Section 804.1 through Section 804.2, shall be provided by the installer at one of the following locations:

1. DC PV system disconnecting means.
2. PV system electronic power conversion equipment.
3. Distribution equipment associated with the PV system. [NFPA 70:690.52(D)(1)]

822.2 Interactive System Point of Interconnection. All interactive system(s) points of interconnection with other sources shall be marked at a location associated with the dc electric power source operating to supply the ac equipment or wiring method and shall not be handwritten and shall be legible.

The warning sign(s) or label(s) shall comply with Section 810.1.2 and 821.2. [NFPA 70:690.13(B)]

824.0 Wiring Methods.

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

1. Exposed raceways, cable trays, and other wiring methods.
2. Covers or enclosures of pull boxes and junction boxes.
3. Conduit bodies in which any of the available conduit openings are unused.

The labels or markings shall be visible after installation. All letters shall be capitalized and shall be a minimum height of 3/8 of an inch (9.5 mm) in white on a red background. Labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors. Spacing between labels or markings, or between a label and a marking, shall not be more than 10 feet (3048 mm). Labels required by this section shall be suitable for the environment where they are installed. [NFPA 70:690.31(D)(2)]

825.0 Facilities with Stand-Alone Systems.

825.1 Plaques or Directories Identification of Power Sources. A permanent plaque, label, or directory shall be installed at a building supplied by a stand-alone system at each service equipment the power source disconnecting means location, or at an approved readily visible location. The plaque, label, or directory shall denote the location of each power source disconnecting means for the building or be grouped with other plaques or directories for other on-site sources. Where multiple sources supply the building, the plaque or directory shall be marked with the wording “CAUTION: MULTIPLE SOURCES OF POWER.” The markings shall comply with Section 810.1.2.4 and 821.1.

Exception: Installations with multiple co-located power production sources shall be permitted to be identified as a group(s). The plaque or directory shall not be required to identify each power source individually. [NFPA 70:710.10]

824.2 Facilities with Utility Services and Photovoltaic Systems. Plaques or directories shall be installed in accordance with Section 821.1, Section 821.2.1, and Section 821.2.2, as required. [NFPA 70:690.56(B)]

824.2.1 Source Directory. A permanent directory denoting all dc electric power sources operating to sup...
ply the dc microgrid shall be installed at each source location capable of acting as the primary dc source. [NFPA 70:712.10(A)]

824.3.2 Building Directory. A building supplied by a dc microgrid system shall have a permanent plaque or directory installed outside the building at each service equipment location or at an approved readily visible location. The plaque or directory shall denote the location of each power source disconnecting means on or in the building or be grouped with other plaques or directories for other on-site sources.

Exception: Multiple power production sources that are grouped at one location shall be permitted to be identified as a group. [NFPA 70:712.10(B)]

824.3 Buildings with Rapid Shutdown. Buildings with PV systems shall have a permanent label located at each service equipment location to which the PV systems are connected or at an approved readily visible location and shall indicate the location of rapid shutdown initiation devices. The label shall include a simple diagram of a building with a roof and shall include the following words:

SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN.

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

The title “SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN” shall utilize capitalized characters with a minimum height of 5/8 of an inch (9.5 mm) in black on yellow background. The remaining characters shall be capitalized with a minimum height of 3/16 of an inch (4.8 mm) in black on white background. All text shall be legible and contrast the background. [NFPA 70:690.56(C) 690.12(D)]

824.3.1 825.2.1 Buildings with More Than One Rapid Shutdown Type. For buildings that have PV systems with more than one rapid shutdown type or PV systems with no rapid shutdown, a detailed plan view diagram of the roof shall be provided showing each different PV system with a dotted line around areas that remain energized after rapid shutdown is initiated. [NFPA 70:690.56(C)(1) 690.12(D)(1)]

824.3.2 825.2.2 Rapid Shutdown Switch. A rapid shutdown switch shall have a label that includes the following wording located on or no more than 3 feet (914 mm) from the switch:

RAPID SHUTDOWN SWITCH FOR SOLAR PV SYSTEM

The label shall be reflective, with all letters capitalized and having a minimum height of 5/8 of an inch (9.5 mm), in white on red background. [NFPA 70:690.56(C)(2) 690.12(D)(2)]

Part VII – Connection to Other Sources.

825.0 826.0 Connection to Other Sources.

825.1 826.1 PV Systems. PV systems connected to other sources shall be installed in accordance with Parts I and II of Article 705 and Article 712 of NFPA 70. [NFPA 70:690.59]


826.0 827.0 Energy Storage Systems.

826.4 827.1 General. An energy storage system connected to a PV system shall be installed in accordance with Part VIII of this chapter and Article 706 of NFPA 70. [NFPA 70:690.71]

827.0 828.0 Batteries.

827.1 828.1 Battery Locations. Battery locations shall comply with the following:

(1) In the absence of the manufacturer’s ventilation recommendations and listing for the system, battery rooms shall be provided with an exhaust rate of not less than 1 cubic foot per minute per square foot [(ft³/min)/ft²] [0.005 (m³/s)/m²] of floor area of the room to prevent the accumulation of flammable vapors. Such exhaust shall discharge directly to an approved location at the exterior of the building.

(2) If ventilation is provided, makeup air shall be provided at a rate equal to the rate that air is exhausted by the exhaust system. Makeup air intakes shall be located so as to avoid recirculation of contaminated air.

(3) Batteries shall be protected against physical damage.

(4) Batteries shall not be located in areas where open use, handling or dispensing of combustible, flammable, or explosive materials occurs.

(5) Combustible materials not related to the stationary storage battery system shall not be stored in battery rooms, cabinets, or enclosures.
**SOLAR PHOTOVOLTAIC SYSTEMS**

**828.0 829.0 Self-Regulating Charge Control.**

**828.1 829.1 General.** The PV source circuit shall be considered to comply with the requirements of Section 828.1.1 through Section 828.1.5 if for charge control of a battery without the use of separate charge control equipment if the circuit meets both of the following:

1. The PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells.
2. The maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer. [NFPA 70:690.72]

**828.1.2 829.1.2 Charge Control.** Provisions shall be provided to control the charging process of the Energy Storage System (ESS). All adjustable means for control of the charging process shall be accessible only to qualified persons. [NFPA 70:706.33(A)]

**828.1.3 829.1.3 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 70:706.33(B)(1)]

**828.1.3 829.1.3 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 70:706.33(B)(2)]

**828.1.4 829.1.4 Energy Storage Systems Using Utility-Interactive Inverters.** Systems using interactive inverters to control energy storage state-of-charge by diverting excess power into an alternate electric power production and distribution system, such as utility, shall comply with the following:

1. These systems shall not be required to comply with Section 828.1.3 829.1.3.
2. These systems shall have a second, independent means of controlling the ESS charging process for use when the alternate system is not available or when the primary charge controller fails or is disabled. [NFPA 70:706.33(B)(3)]

**828.1.5 829.1.5 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 70:706.33(C)]

**Part IX – Large-Scale Photovoltaic (PV) Electric Power Production Facility.**

**829.0 830.0 Large-Scale Photovoltaic (PV) Electric Power Production Facility.**

**829.1 830.1 Scope.** Section 829.2 through Section 829.9 Part IX of this chapter covers the installation of large-scale PV electric supply stations with an inverter generating capacity of no less than 5000 kW, and not under exclusive utility control. [NFPA 70:691.1] (See Figure 830.1)

**FIGURE 830.1**

**1, 2**

**IDENTIFICATION OF LARGE-SCALE PV ELECTRIC SUPPLY STATION COMPONENTS**

[NFPA 70:FIGURE 691.1]

**Notes:**

1. The diagram is for informational purposes only and is not representative of all potential configurations.
2. Custom designs occur in each configuration, and some components are optional.

**829.2 830.2 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 810.4.3 821.2.
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.

(6) The station shall be monitored from a central command center.

(7) The station shall have an inverter generating capacity of at least 5000 kW. [NFPA 70:691.4]

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

(1) Listing and labeling.

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

(3) Where products complying with Section 829.3(1) or Section 829.3(2) Section 830.3(1) or Section 830.3(2) are not available, by engineering review validating that the electrical equipment is evaluated and tested to relevant standards or industry practice. [NFPA 70:691.5]

829.4 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 Authority Having Jurisdiction. 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]

829.5 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]

829.6 Direct-Current Operating Voltage. For large-scale PV electric supply stations, calculations shall be included in the documentation required in Section 830.4. [NFPA 70:691.8]

829.7 Disconnection of Disconnecting Means for Isolating Photovoltaic Equipment. Isolating devices Disconnecting means for equipment shall not be required within sight of equipment and shall be permitted to be located remotely from equipment. The engineered design required by Section 829.4 shall document disconnection procedures and means of isolating equipment.

829.8 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 829.4. [NFPA 70:691.9]

829.9 Fence Bonding and Grounding. Fence grounding requirements and details shall be included in the documentation required in Section 829.4. [NFPA 70:691.11]
CHAPTER 9
REFERENCED STANDARDS

901.0 General.
901.1 Standards. The standards listed in Table 901.1 are referenced in various sections of this code and shall be considered part of the requirements of this document. The standards are listed herein by the standard number and effective date, the title, application and the section(s) of this code that reference the standard. The application of the referenced standard(s) shall be as specified in Section 302.1.2. The promulgating agency acronyms referred to in Table 901.1 are defined in a list found at the end of the chapter.

### TABLE 901.1
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### REFERENCED STANDARDS

901.2 Standards, Publications, Practices, and Guides. The standards, publications, practices and guides listed in Table 901.2 are not referenced in other sections of this code. The application of the referenced standards, publications, practices and guides shall be as specified in Section 302.1.2. The promulgating agency acronyms are found at the end of the table.

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ABBREVIATIONS IN TABLE 901.1 AND TABLE 901.2

ANSI  American National Standards Institute, Inc., 25 W. 43rd Street, 4th Floor, New York, NY 10036.
ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
ASME American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.
ASSE American Society of Sanitary Engineering, 18927 Hickory Creek Drive, Suite 220, Mokena, IL 60448.
ASTM ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.
AWS American Welding Society, 8669 NW 36 Street, # 130, Miami, FL 33166-6672.
AWWA American Water Works Association, 6666 W. Quincy Avenue, Denver, CO 80235.
CSA Canadian Standards Association, 178 Rexdale Boulevard, Toronto, ON, Canada M9W 1R3.
e1 An editorial change since the last revision or reapproval.
IAPMO International Association of Plumbing and Mechanical Officials, 4755 E. Philadelphia Street, Ontario, CA 91761.
IEEE The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, 17th Floor, New York, NY 10016-5997.
ISO International Organization for Standardization, 1 ch. de la Voie-Creuse, Casa Postale 56, CH-1211 Geneva 20, Switzerland.
MSS Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street NE, Vienna, VA 22180.
NEMA National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1752, Rosslyn, VA 22209.
NFPA National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.
NGWA National Ground Water Association, 601 Dempsey Road, Westerville, OH 43081.
NSF NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.
SRCC Solar Rating and Certification Corporation, 3060 Saturn Street, Suite 100, Brea, CA 92821.
UL Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062.
APPENDICES

The appendices are intended to supplement the provisions of the installation requirements of this code. The definitions in Chapter 2 are also applicable to the appendices.

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APPENDIX A
ENGINEERED SOLAR ENERGY SYSTEMS

A 101.0 General.
A 101.1 Applicability. The provisions of this appendix shall apply to the design, installation, and inspection of an engineered solar energy system, alternate materials, and equipment not specifically covered in other parts of the code.

A 101.2 Authority Having Jurisdiction. The Authority Having Jurisdiction has the right to require descriptive details of an engineered solar energy system, alternate material, or equipment including pertinent technical data to be filed.

A 101.3 Conformance. Components, materials, and equipment shall comply with standards and specifications listed in Table 901.1 of this code and other national consensus standards applicable to solar energy systems and materials.

A 101.4 Alternate Materials and Equipment. Where such standards and specifications are not available, alternate materials and equipment shall be approved in accordance with Section 302.2 of this code.

A 102.0 Engineered Solar Energy Systems.
A 102.1 Definition. For purposes of this appendix, the following definition shall apply:

Engineered Solar Energy System. A system designed for a specific building project with drawings and specifications indicating materials to be installed, all as prepared by a person registered or licensed to perform solar energy system design work.

A 102.2 Inspection and Installation. In other than one- and two-family dwellings, the designer of the system shall provide periodic inspection of the installation on a schedule found suitable to the Authority Having Jurisdiction. Prior to the final approval, the designer shall verify to the Authority Having Jurisdiction that the installation is in compliance with the approved plans, specifications, and data and such amendments thereto. The designer shall also certify to the Authority Having Jurisdiction that the installation is in compliance with the applicable engineered design criteria.

A 102.3 Owner Information. The designer of the system shall provide the building owner with information concerning the system, considerations applicable for subsequent modifications to the system, and maintenance requirements.

A 103.0 Water Heat Exchangers.
A 103.1 Protection of Potable Water System. Heat exchangers used for heat transfer, heat recovery, or other solar thermal purposes shall protect the potable water system from being contaminated by the heat-transfer medium.

A 103.2 Where Permitted. Single-wall heat exchangers shall be permitted where they satisfy the following requirements:

1. The heat-transfer medium is either potable water or contains nontoxic fluids recognized as safe by the Food and Drug Administration (FDA) as food grade.
B 101.0 General.
B 101.1 Applicability. This appendix provides installation guidelines for solar PV systems for commercial buildings and residential housing comprised of three or more units. Provisions contained in these guidelines shall not apply unless specifically adopted by local ordinance in accordance with Section 102.8.

These guidelines shall not apply to non-habitable structures (e.g., parking shade structures, solar trellises, etc.).

B 101.2 Alternate Materials and Methods. Alternate materials and methods shall be approved in accordance with Section 302.2.

B 102.0 Marking.
B 102.1 General. Photovoltaic (PV) systems shall be marked. Materials used for marking shall be weather resistant in accordance with Part VI of Chapter 8.

B 102.2 Main Service Disconnect. The marking shall be placed adjacent to the main service disconnect in a location visible from where the lever is operated.

B 102.2.1 Marking Content and Format. Marking content and format for main service disconnects shall comply with the following:

(1) Marking content:
CAUTION: SOLAR ELECTRIC SYSTEM CONNECTED

(2) Red background
(3) White lettering
(4) Minimum ¾ of an inch (9.5 mm) letter height
(5) Capital letters
(6) Arial or similar font, non-bold
(7) Reflective, weather-resistant material (durable adhesive materials shall meet this requirement)

B 102.3 Marking for Direct-Current Conduit, Raceways, Enclosures, Cable Assemblies, and Junction Boxes. Markings shall be required on interior and exterior dc conduit, raceways, enclosures, cable assemblies, and junction boxes. Markings shall be placed on interior and exterior dc conduit, raceways, enclosures, and cable assemblies every 10 feet (3048 mm), at turns; on both sides of a penetration; and at dc combiner and junction boxes.

B 102.3.1 Marking Content and Format. Marking content and format for direct-current conduit, raceways, enclosures, cable assemblies, and junction boxes shall comply with the following:

(1) Marking content:
CAUTION: SOLAR CIRCUIT

(2) Red background
(3) White lettering
(4) Minimum ¾ of an inch (9.5 mm) letter height
(5) Capital letters
(6) Arial or similar font, non-bold
(7) Reflective, weather-resistant material (durable adhesive materials shall meet this requirement)

B 102.4 Inverters. Markings shall not be required for the inverter.

B 103.0 Access, Pathways, and Smoke Ventilation.
B 103.1 General. Access and spacing of PV modules shall comply with Section B 103.2 through Section B 103.4.

Where the Authority Having Jurisdiction determines that the roof configuration is similar to residential (such as in the case of townhouses, condominiums, or single family attached buildings), the access and ventilation requirements of IAPMO IS 34 shall be permitted. See Figure B 103.1(1) through Figure B 103.1(4).

B 103.2 Access. There shall be not less than a 6 feet (1829 mm) wide clear perimeter around the edges of the roof. Where either axis of the building is 250 feet (76 200 mm) or less, there shall be not less than a 4 feet (1219 mm) wide clear perimeter around the edges of the roof.

B 103.3 Pathways. Pathways shall be established in the design of the solar installation. Pathways shall be provided in accordance with the following:

(1) Pathways shall be located over structural members.
(2) Centerline axis pathways shall be provided in both axis of the roof. Centerline axis pathways shall run on structural members or over the next closest structural member nearest to the center lines of the roof.
(3) Shall be a straight line not less than 4 feet (1219 mm) clear to skylights, ventilation hatches, or both.
(4) Shall be a straight line not less than 4 feet (1219 mm) clear to roof standpipes.
(5) There shall be not less than a 4 foot (1219 mm) clearance around roof access hatches, skylights, ventilation hatches, roof standpipes, and similar obstructions.
(6) There shall be not less than one 4 foot (1219 mm) clear pathway to parapets or roof edges.

B 103.4 Smoke Ventilation. Smoke ventilation shall be provided in accordance with the following:

(1) Arrays shall not exceed 150 feet (45 720 mm) by 150 feet (45 720 mm) in distance in either axis.
(2) Ventilation between array sections shall be provided with one of the following:
   (a) A pathway 8 feet (2438 mm) or greater in width.
(b) A pathway 4 feet (1219 mm) or greater in width that borders existing roof skylights or ventilation hatches.

(c) A pathway 4 feet (1219 mm) or greater in width that borders 4 feet (1219 mm) by 8 feet (2438 mm) venting cutouts every 20 feet (6096 mm) on alternating sides of the pathway.

**B 104.0 Location of Direct-Current (dc) Conductors.**

**B 104.1 General.** Conduit, wiring systems, and raceways for photovoltaic circuits shall comply with NFPA 70 and be located as close as possible to a ridge, hip, or valley; and from the hip or valley as directly as possible to an outside wall.

Conduit runs between subarrays and dc combiner boxes shall be the shortest path from the array to the dc combiner box. The dc combiner boxes shall be located such that conduit runs are minimized in the pathways between arrays.

Direct-Current (dc) wiring shall be ran in metallic conduit or raceways where located within enclosed spaces in a building and shall be ran along the bottom of structural members.

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**FIGURE B 103.1(1)**

*SOLAR ARRAY INSTALLATION ON LARGE COMMERCIAL BUILDINGS WITH 8 FOOT WALKWAYS*
FIGURE B 103.1(2)
SOLAR ARRAY INSTALLATION ON LARGE COMMERCIAL BUILDINGS WITH 4 FOOT WIDE WALKWAYS WITH 8 FOOT BY 4 FOOT VENTING CUTOUTS EVERY 20 FOOT LENGTH

FIGURE B 103.1(3)
SOLAR ARRAY INSTALLATION ON SMALL COMMERCIAL BUILDINGS WITH 4 FOOT WIDE WALKWAYS WITH 8 FOOT BY 4 FOOT VENTING CUTOUTS EVERY 20 FOOT LENGTH
FIGURE B 103.1(4)
SOLAR ARRAY INSTALLATION ON SMALL COMMERCIAL BUILDINGS WITH 8 FOOT WIDE WALKWAYS

For SI units: 1 foot = 304.8 mm
C 101.0 General.
C 101.1 Applicability. The provisions of this appendix shall apply to solar ready construction for low-rise residential buildings.
C 101.2 Permit. Where solar ready construction is required by the Authority Having Jurisdiction, plans and construction documents in accordance with Section C 101.3 shall be submitted with the building permit application.
C 101.3 Plans and Construction Documents. Plans for solar zones shall include connections to a solar photovoltaic (PV), solar thermal system, or both. A copy of the construction documents shall be provided to the building occupant.

The construction documents shall include the following:
1. Structural design loads for the solar zone in accordance with the building code.
2. Conduit pathway from the solar zone to the point of interconnection.
3. For solar PV systems, the location for future installation of inverters and metering equipment.
4. For solar thermal systems, the plumbing pathway from the solar zone to the water heating system.

C 102.0 Definitions.
C 102.1 General. For the purposes of this appendix, the following definitions shall apply:

Solar Access. The ratio of solar insolation including shading to that without shading.
Solar Ready. The design and construction of a building which provides locations for future solar thermal and solar PV system installations and connections.
Solar Zone. The total area of an available and appropriate space to be used for future solar PV or solar thermal installation.
Solar Zone, Potential. A portion of the solar zone with an annual solar access of at least 70 percent.

C 103.0 Solar Zones.
C 103.1 General. Solar zones shall be determined in accordance with Section C 103.2 through Section C 103.5.1.
C 103.2 Location. Solar zones shall be located on approved structures in accordance with the building code. Solar zones shall comply with the access, pathway, and setback requirements of the fire code and IAPMO IS 34.
C 103.3 Orientation. Solar zones located on roofs with a slope of not less than two units vertical in twelve units horizontal (2:12) shall be oriented between 90 degrees and 270 degrees true north.
C 103.4 Shading. Solar zones shall be unshaded and have an annual solar access of at least 70 percent.

C 103.5 Minimum Area. The solar zone shall not include obstructions and penetrations. Where the total roof area is not less than 600 square feet (ft²) (55.74 m²), the solar zone shall not be less than 300 square feet (ft²) (27.87 m²).

Exceptions:
1. Where the total roof area is not less than 600 square feet (ft²) (55.74 m²) and has less than 70 percent annual solar access, the solar zone shall not be less than 50 percent of the potential solar zone.
2. Where approved by the Authority Having Jurisdiction, a smaller solar zone shall be permitted.
C 103.5.1 Subareas. The total solar zone shall be permitted to be the sum of multiple subareas. No dimension of a subarea shall be less than 5 feet (1524 mm). Where the total roof area exceeds 10 000 square feet (ft²) (929 m²), each subarea shall not be less than 160 square feet (ft²) (14.9m²). Where the total roof area is less than 10 000 square feet (ft²) (929 m²), each subarea shall not be less than 80 square feet (ft²) (7.4 m²).

C 103.5.2 Example. A house with a total roof area of 3 000 square feet (ft²) (278.7 m²) has a potential solar zone area of 500 square feet (ft²) (46.5 m²). Determine the minimum size of the solar zone.

$$500 \text{ ft}^2 \times 0.5 = 250 \text{ ft}^2 (23.2 \text{ m}^2)$$
APPENDIX D
INSTALLATION OF RESIDENTIAL SOLAR PHOTOVOLTAIC
AND ENERGY STORAGE SYSTEMS

Part I – General.

D 101.0 General.

D 101.1 Applicability. Part I of this appendix is intended to provide guidelines for the installation of solar photovoltaic (PV) and energy storage systems (ESS) in residential applications. [See Figure D 101.1(1) through Figure D 101.1(4) for typical arrangements of solar PV systems with a direct-current (dc) string inverter, power distribution, utility demand response, or net energy metering (NEM).]

D 101.2 Approval Required. An installed solar PV system shall not begin operation before approval is granted by the Authority Having Jurisdiction and the local utility.

D 101.3 Electrical Requirements. Electrical connections, wiring, and devices shall be installed in accordance with NFPA 70.

D 101.3.1 Listing and Labeling. PV equipment shall be listed or labeled in accordance with the appropriate standard, as listed in Table 802.2.1. Equipment used in PV systems shall be listed or field labeled, or evaluated for the application and have a field labeled applied.

D 101.4 Code Requirements. The installation of a solar PV system shall comply with this code, the mechanical code, the plumbing code, and NFPA 70; or the code requirements as adopted by the Authority Having Jurisdiction.

D 102.0 Definitions.

D 102.1 General. For the purpose of this appendix, the following definitions shall apply:

Constraints. A limitation on the design or ability of an ESS.

Dwelling Unit. A structure, or part of a structure, which serves as a place of residence and provides complete living facilities for one or more persons.

Dynamic Model of Microgrid. The expected or actual behavior of the microgrid (simulated or modeled) which accounts for load, storage, and time.

Energy Storage System. A device which stores energy for later consumption.

Learning-Based GHI Prediction. Predictions initially based on the GHI algorithm and adjusts based on machine inputs and changing parameters.
FIGURE D 101.1(2)
SOLAR PV SYSTEM – POWER DISTRIBUTION

FIGURE D 101.1(3)
SOLAR PV SYSTEM – UTILITY DEMAND RESPONSE
Learning-Based Load Prediction. An algorithm taking into account expected load consumption for the purpose of meeting the demands generated by inputs and parameters.

Microgrid Interconnection Device. A device which provides a microgrid system with a means of disconnecting from and reconnecting with a primary power source to function in parallel.

Net Energy Metering. The use of any bi-directional meter (e.g. analog, electro-mechanical, smart, radio frequency, etc.) to measure the energy difference between the amount supplied by the utility grid and the amount the utility grid receives from user generation.

Objective Function. The programmed function that is designed to arrive at a particular strategy to achieve the goals of the system. Goals may include peak shaving, utility bill cost deduction, emergency storage, or any combination of desired goals within the strategy.

Plan View. An orthographic projection of the three-dimensional roof or structure, serving as a space for solar PV installation, from the position of a horizontal plane.

Power Command. The ESS designed and demanded power being called to the user’s facility or systems.

Short-Term GHI Prediction. Predictions based on the GHI algorithm that depicts as little as a few minutes or as long as a few days.

Short-Term Load Prediction. Load predictions based on expectations within the next few minutes to the next few days.

Smart Meter. An electrical meter which features two-way communication with the central computer system and records data including both electrical usage and service characteristics for voltage, amperage, and power factor.

Solar Access. The ratio of solar insolation including shading to that without shading.

Solar Zone. The total area of an available and appropriate space to be used for future solar PV installation.

Solar Zone, Potential. A portion of the solar zone with an annual solar access of at least 70 percent.

State of Charge. The current amount of charge in the battery at a given time.

D 103.0 Plan Details.

D 103.1 General. Plan details shall be generated and submitted to the Authority Having Jurisdiction (Authority Having Jurisdiction) for approval before the installation of a solar PV system or an energy storage system. Site plans shall be sized and formatted in accordance with the Authority Having Jurisdiction.

Plan details for a solar PV system shall be in accordance with Section D 103.2 through Section D 103.2.7 and the requirements specified by the Authority Having Jurisdiction.

Plan details for a solar photovoltaic with energy storage systems (PV-ESS) shall be in accordance with Section D 103.3 and Section D 103.3.1 and the requirements specified by the Authority Having Jurisdiction.

See Figure D 103.1(1) through Figure D 103.1(4) for typical PV-ESS components and configurations. See Figure D 103.1(5) for an example of a combiner box installed with PV-ESS. See Part V for sample site plans for residential PV systems.

D 103.2 PV System Details. The following shall be provided with the plan details of a PV system:
(1) Scope of the project, including the dc system kW•h (J) rating, system architecture, and racking type

(2) A complete single line diagram including the following:
   (a) Utility interconnect
   (b) Disconnecting means in accordance with Chapter 8 (Part III) or NFPA 70
   (c) Alternating-current (ac) disconnect switch with visible blades and lockable handle
   (d) Solar to utility Point of Connection (POC)
   (e) Maximum ratings
   (f) Enclosure types
   (g) Model numbers
   (h) Module strings to MPPTs
   (i) Applicable facility loads

(3) A site plan, identifying the location of system components including, but not limited to, the following:
   (a) Modules on the roof
   (b) Equipment on the wall
   (c) Disconnecting means
   (d) Cross streets
   (e) Property line
   (f) Fire access points
   (g) Pathways
   (h) Obstructions on the roof
   (i) North arrow

(4) Type of system (i.e. ac modules, bipolar, grounded, ungrounded, hybrid, isolated, interactive, stand-alone, etc.)

(5) Utility service operating voltage or class

(6) Information on the size, type, and number of conductors of the dc and ac side of the PV system

(7) Type and size of raceway(s)

(8) Roof plan, including access points, pathways, and roof mounted equipment

(9) The following information shall be provided for the dc side of the PV system:
   (a) Number of series-connected modules for each PV source circuit
   (b) Number of parallel-connected modules or panel PV source circuits for each array or PV power source
   (c) Number of combiner boxes, control boxes, or PV power centers for each array, subarray, or PV power source
   (d) Number of PV output circuits
   (e) Maximum array, panel, or module system voltage
      (i) Maximum ac or dc string voltage
   (f) Short circuit current of modules or panels
      (i) Specification sheet
   (g) Short circuit current of battery system
      (i) Specification sheet
   (h) Disconnecting means electrical ratings including the following:
      (i) Voltage
      (ii) Maximum current
      (iii) Number of poles
   (i) The manufacturer’s specifications shall be provided for the PV modules or panels. The manufacturer’s specifications shall include the manufacturer’s name, catalog numbers, complete electrical information, maximum series fuse rating, and installation instructions.

(j) The manufacturer’s specifications shall be provided for inverters, converters, charge controllers, and ac modules, indicating the following ratings:
   (i) Maximum input ac and dc voltage, and the range of operating voltage(s)
   (ii) Nominal ac output voltage
   (iii) Nominal dc voltage and operating range for utility interactive or stand-alone systems with charge controller(s)
   (iv) Maximum input ac and dc, and maximum input short circuit current
   (v) Maximum inverter output short circuit current and duration
   (vi) Normal operation temperature range

(k) Information indicating where the inverter(s) or charge controller(s) contains current limiting devices that limits the output circuit current to the maximum inverter input dc current rating

(l) The manufacturer’s specifications shall be provided for combiner boxes, control boxes, PV power centers, or rapid shutdown equipment. It shall contain the manufacturer’s name, model designation, and listing.

(m) The manufacturer’s specifications shall be provided for each connector indicating configuration, construction, type, and grounding member.

(n) Where the PV-ESS system uses a diversion charge controller as the sole means of regulating the charging of a battery, a second independent means of preventing the storage device from overcharging shall be provided.

(o) Methods of access to the junction, pull, or outlet boxes behind the modules or panels

D 103.2.1 Circuits. Circuit requirements shall be indicated in the plan details in accordance with Chapter 8 (Part II) or the following:

(1) Circuit conductors and overcurrent protective devices shall be sized to carry not less than 125 percent of the maximum current as determined in accordance with NFPA 70.

(2) Overcurrent protection of output circuits with internal current limiting devices shall be not less than 125 percent of the maximum limited current of the output circuit. The conductors in such an output circuit shall be sized in accordance with NFPA 70.
(3) Common-return conductor of systems with multiple voltages shall not be smaller than the sum of the ampere ratings of the overcurrent devices of the individual output circuits.

(4) Where a single overcurrent device is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall be not less than the sum of the fuse ratings and 125 percent of the short circuit from the other parallel-connected modules.

D 103.2.2 Overcurrent Protection. Circuits connected to more than one electrical source shall have overcurrent protective devices that provide overcurrent protection from sources indicated on the plan details.

D 103.2.3 Disconnecting Means. Disconnecting means shall be provided in the plan details for the following:

(1) PV source circuits (isolating switches with visible blade and lockable handle)

(2) Inverters

(3) Batteries

(4) Charge controllers where applicable

   The PV disconnecting means shall be grouped together, and the number of disconnects shall not exceed six.

D 103.2.4 Grounding. Grounding shall be indicated in the plan details as follows:

(1) Where components of the system are negatively or positively grounded.

(2) The dc circuit grounding shall be made at a single point on the PV output circuit.

(3) The equipment-grounding conductor for a PV source and PV output circuits for a roof mounted dc PV array in dwellings shall be sized in accordance with NFPA 70.

(4) Grounding electrode system used for the ac, dc, or combined ac/dc systems.

(5) The method used to ensure the removal of equipment from the system that shall not disconnect the bonding connection between the grounding electrode conductors and exposed conducting surfaces.

(6) The method used to ensure the removal of a utility-interactive inverter or other equipment that shall not disconnect the bonding connection between the grounding electrode conductor and the PV source and the output circuit grounded conductor, or both.

(7) The ground rod details shall be provided. See Figure D 103.2.4 for an example of ground rod details.

D 103.2.5 Ground-Fault Protection. Direct-current ground-fault protection for dwellings with roof mounted dc PV arrays shall be provided on the plan details.

D 103.2.6 Systems Over 1000 Volts. Plan details for PV systems over 1000 volts shall indicate the following:

(1) The PV system is in accordance with Chapter 8 or NFPA 70, and other applicable installation requirements.

(2) The voltage rating of a battery circuit cable shall not be smaller than the charging or equalizing condition of the battery system.
D 103.2.7 Calculations. Calculations shall be provided for solar PV systems in accordance with the following:

(1) The maximum system voltage calculation shall be based on the following:
   (a) Extreme annual mean minimum design dry bulb temperature in accordance with ASHRAE Handbook – Fundamentals, and
   (b) Correction factors for ambient temperatures in accordance with Table 804.1.1 or NFPA 70.

(2) The maximum system open-voltage calculation shall be based on the maximum PV system dc voltage (600 V) for PV power source modules made of materials other than crystalline or multi-crystalline silicon.
   (a) For PV systems with dc-to-dc converters:
      (i) The maximum number of dc-to-dc converters in a series shall be calculated based on manufacturer’s instructions, or
      (ii) For multiple dc-to-dc converters in series, the sum of the maximum voltage output of the dc-to-dc converter outputs in the series.
   (b) For PV systems without dc-to-dc converters using the following formula:

\[
V_{\text{MAX}} = V_{\text{OC, Module}} \times N_M \times CF
\]

Where:
- \( CF \) = Correction factor as determined in accordance with Section D 103.2.7 (1)(b)
- \( V_{\text{MAX}} \) = Maximum voltage (V)
- \( V_{\text{OC, Module}} \) = Maximum open circuit voltage per module (V)
- \( N_M \) = Number of modules in series

(3) The maximum dc circuit current calculation for each PV source circuit.

(4) The maximum dc current calculation for each PV output circuit.

(5) The fault current calculation from the utility side to the ac disconnect(s) and inverter(s).

(6) Calculations to determine the minimum overcurrent protective device rating for the dc side. Photovoltaic system currents shall be considered as continuous.

(7) Calculations showing the size of equipment-grounding conductor for the PV source and PV output circuit size shall be not less than 125 percent of the short circuit current from the PV source.

(8) Calculations showing the required maximum charging current of the interconnected battery cells.

(9) Calculations for the ampacity of the neutral conductor of a two-wire inverter output connected to the ungrounded conductors of a three-wire or a three-phase, four-wire system.

(10) Calculations showing that the total dc leakage current in the dc ground or dc grounded circuits in non-isolated PV systems do not exceed the equipment ground-fault protective device leakage current trip setting.

(11) Calculations showing the required current and voltage ratings of dc diversion charge controllers and diversion loads in a circuit.

(12) Calculations showing the required conductor ampacity and overcurrent protective device rating for circuits containing dc diversion charge controllers and diversion loads.

(13) Calculations showing where expansion fittings are not required for the roof mounted raceways due to thermal expansion or building expansion joints where the raceway is used as an equipment grounding conductor.

D 103.3 Energy Storage System (ESS) Details. The following shall be provided with the plan details of an ESS:

(1) Scope of the project, including the system kW rating and system architecture. (i.e. dc or ac coupled, etc).

(2) Complete single line diagram including the following:
   (a) Utility point of interconnection in accordance with NFPA 70
   (b) Disconnecting means in accordance with Chapter 8 (Part III) or NFPA 70
   (c) All relevant new and existing circuits including, but not limited to, conductor, conduit size, type, and number of conductors
   (d) Overcurrent protective device rating
   (e) Enclosure type maximum ratings in accordance with ANSI/NEMA 250
   (f) Model numbers for new and existing service equipment
   (g) Applicable facility loads that are not backed up
   (h) Backup loads
   (i) Grounding and bonding detail
   (j) Combiner boxes and MIDs

(3) A site plan identifying the location of system components including, but not limited to, the following:
   (a) Name and address of the property
   (b) Legend or key for the site plan
   (c) Plan view of the site
   (d) Cross streets
   (e) Property line
   (f) Gates or fences
   (g) Clearance from obstructions
   (h) Clearance from property lines
   (i) North Arrow
   (j) Equipment on the wall
   (k) Disconnecting means
   (l) Service drop location and overhead conductors as required by the Authority Having Jurisdiction
(m) Trench locations containing ESS circuits
(n) Location of hidden hazards including, but not limited to, trenched or exposed overhead conductors

(4) Detailed elevation drawings of the proposed ESS installation including the following:
(a) Working clearances
(b) Spacing and separation of not less than 3 feet (914 mm) between individual units unless smaller separation distances are documented through large scale fire testing
(c) Spacing and separation of not less than 3 feet (914 mm) from doors and windows entering a dwelling unit unless smaller separation distances are documented through large scale fire testing
(d) Hazardous containment where required by the Authority Having Jurisdiction
(e) Method and location of ventilation equipment for indoor installations in accordance with Section 828.1 or NFPA 70

(5) Utility service operating voltage or class

(6) The manufacturer’s specifications for the ESS including the following:
(a) Manufacturer’s name
(b) Catalog numbers
(c) Complete electrical information
(d) Physical dimensions
(e) Maximum recommended overcurrent protective device rating
(f) Current product safety listing
(g) Enclosure environmental rating
(h) Safety data sheet (SDS)

(7) The manufacturer’s installation instructions for the ESS including the following:
(a) Wiring diagram
(b) Nominal dc voltage and operating range for utility interactive or stand-alone systems with charge controller(s)
(c) Environmental considerations
   (i) Normal operating temperature range
   (ii) Location restrictions
   (iii) Spacing and separation requirements as detailed in large scale fire testing
(d) Battery mounting detail
   (i) Indication of whether the ESS is to be wall mounted, wall supported, or floor mounted
   (ii) Where the weight of the ESS, combined or individual on the same wall, is greater than 200 lb (90.7 kg), the structural details and calculations stamped by a licensed structural engineer shall be provided.
   (iii) Where an ESS is installed in a garage, warehouse, or other area subject to mechanical damage, the ESS shall be guarded against such damage by being installed behind protective barriers or by being elevated or located out of the normal path of vehicles. The mounting of an ESS shall be included in the plan details.
(e) Minimum clearances for enclosures

(8) The manufacturer’s specifications shall be provided for panels, combiner boxes, control boxes, power control systems, and disconnecting means. Such specifications shall contain the manufacturer’s name, model designation, and listing.

(9) The manufacturer’s specifications shall be provided for each connector indicating configuration, construction, type, and grounding member.

(10) Where the ESS system uses a diversion charge controller as the sole means of regulating the charging of a battery, a second independent means of preventing the storage device from overcharging shall be provided.

(11) Exclusions, exceptions, or variances from the manufacturer’s specifications, these standards, or the rules from the Authority Having Jurisdiction, shall be listed prominently on the drawings or the engineer’s specifications. These notes shall be annotated with the reason(s) for the modifications to said documents.

D 103.3.1 Arc-Fault Circuit Protection. Arc-fault circuit protection shall be provided in accordance with Section 808.0 and NFPA 70.
Note: This is a simplified representation of a residential PV-ESS and does not include all possible equipment arrangements or configurations. For particular jurisdiction interconnection requirements, please refer to the local utility and code requirements.
Note: This diagram represents one configuration of PV-ESS which does not feed excess energy to the utility grid. Equipment arrangements and configurations may vary.

FIGURE D 103.1(3)
PV+DC-COUPLED ESS CONFIGURATION WITHOUT GRID EXPORT (SIMPLIFIED)

Note: This diagram represents one configuration of PV-ESS which feeds excess energy to the utility grid. Equipment arrangements and configurations may vary.

FIGURE D 103.1(4)
PV+DC-COUPLED ESS CONFIGURATION WITH GRID EXPORT (SIMPLIFIED)
D 104.0 Installation Requirements.

D 104.1 General. PV systems installed on a structure or rack shall be in accordance with Section D 104.2 through Section D 104.2.3.1. Ground-mounted PV systems shall be in accordance with Section D 104.3.

D 104.2 Residential Systems – One- and Two-Unit Residential Dwellings. Plan review shall be required, in accordance with the Authority Having Jurisdiction and the utility, where a PV system is installed on a structure or a rack.

D 104.2.1 Solar Zones. Where new construction of a one- or two-unit residential dwelling is installed with a solar zone, the solar zone shall be in accordance with the Authority Having Jurisdiction and the following:

1. Unshaded and free from obstructions
2. Located 90 degrees to 270 degrees true north
3. For roof areas not less than 600 square feet (55.74 m²), the solar zone shall be not less than 300 square feet (27.87 m²) exclusive of the setback requirements in Section D 104.2.2.3.1.

Exception: Where a roof area is not less than 600 square feet (55.74 m²) and has less than 70 percent annual solar access, the solar zone shall not be less than 50 percent of the potential solar zone.

D 104.2.2 Access, Pathways, and Setbacks. Roof access shall be provided in accordance with Section D 104.2.2.1. Pathways and setbacks shall be in accordance with Section D 104.2.2 through Section D 104.2.2.3.1. See Figure D 104.2.2(1) through Figure D 104.2.2(14) for illustrations of pathways, setbacks, and access.

D 104.2.2.1 Access. Roof access for emergency services shall be provided to pathways specified in Section D 104.2.2.2 or Section D 104.2.2.3 and shall be located in areas without obstructions. Roof access points and ladders shall be located over areas which do not block windows, doors, or other openings. Minimal spacing for smoke ventilation shall be in accordance with Section D 104.2.3.

D 104.2.2.2 Pathways – Flat Roofs. Where roofs are installed with slopes less than two units vertical in twelve units horizontal (2:12), a 3 foot (914 mm) wide clear pathway shall be provided around the perimeter of the roof plane. Pathways shall be located over areas capable of supporting the live load of fire fighters with all associated gear.

D 104.2.2.3 Pathways – Sloped Roofs. Where roofs are installed with slopes not less than two units vertical in twelve units horizontal (2:12), pathways shall be provided in accordance with the following:

1. There shall be not less than one 3 foot (914 mm) wide pathway provided for each roof plane where a module is installed. The pathway shall be located from the eave to the ridge on the same roof plane as the modules, straddling the same and adjacent plane, or on an adjacent plane.
2. Modules, on a roof with a ridge, shall be located in a manner that provides two separate 3 foot (914 mm) wide pathways from the eave to the ridge on separate roof planes.
APPENDIX D

FIGURE D 104.2.2(1)
PATHWAYS AND SETBACKS ON CROSS GABLE ROOF

FIGURE D 104.2.2(2)
PATHWAYS AND SETBACKS ON CROSS GABLE ROOF WITH VALLEY

For SI units: 1 foot = 304.8 mm
For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(3)
PATHWAYS AND SETBACKS ON FULL GABLE ROOF

For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(4)
PATHWAYS AND SETBACKS ON FULL HIP ROOF
For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(5)
PATHWAYS ACCOUNTING FOR OBSTRUCTIONS

For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(6)
FIRE ACCESS AND SETBACKS
APPENDIX D

For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(7)
PATHWAYS AND SETBACKS WHERE PV MODULES OCCUPY LESS THAN \( \frac{1}{3} \) OF ROOF AREA (DRIVEWAY ACCESS)

For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(8)
RIDGE PATHWAYS AND SETBACKS WHERE PV MODULES OCCUPY LESS THAN \( \frac{1}{3} \) OF ROOF AREA
FIGURE D 104.2.2(9)
RIDGE PATHWAYS AND SETBACKS WHERE PV MODULES OCCUPY MORE THAN \( \frac{1}{3} \) OF ROOF AREA
(DRIVEWAY ACCESS)

FIGURE D 104.2.2(10)
HIP, VALLEY, AND RIDGE PATHWAYS AND SETBACKS WHERE PV MODULES OCCUPY MORE THAN \( \frac{1}{3} \) OF ROOF AREA
(ALTERNATE DRIVEWAY ACCESS)
For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(11)
RIDGE PATHWAYS AND SETBACKS WHERE PV MODULES OCCUPY MORE THAN \( \frac{1}{3} \) OF ROOF AREA
(STREET ACCESS)

For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(12)
RIDGE PATHWAYS AND SETBACKS WHERE PV MODULES OCCUPY MORE THAN \( \frac{1}{3} \) OF ROOF AREA
For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(13)
RIDGE PATHWAYS AND SETBACKS ACCOUNTING FOR OBSTRUCTIONS

For SI units: 1 foot = 304.8 mm

FIGURE D 104.2.2(14)
RIDGE PATHWAYS AND SETBACKS ACCOUNTING FOR LARGE OBSTRUCTIONS
(3) Modules, adjacent to hips and valleys, shall be located not less than 18 inches (457 mm) from a hip or a valley where modules are to be placed on both sides of a hip or valley. Where modules are to be located on one side of a hip or valley that is of equal length, modules shall be permitted to be placed directly adjacent to the hip or valley.

(4) There shall be not less than one pathway provided on the driveway or street side of the roof.

(5) Pathways shall be located in areas with minimal obstructions (e.g. chimneys, vents, conduit, and mechanical equipment).

D 104.2.3.1 Alternate Setback at Ridge. Both sides of a horizontal ridge shall have an unobstructed setback in accordance with the following:

(1) Where PV arrays occupy more than one-third of the total plan view roof area, a 3 foot (914 mm) wide setback shall be required.

(2) Where PV arrays occupy not more than one-third of the total plan view roof area, a setback of not less than 18 inches (457 mm) wide shall be required.

Exceptions:

(1) Where an automatic sprinkler system in accordance with NFPA 13D is installed and PV arrays occupy not more than two-thirds of the total plan view roof area, a setback of not less 18 inches (457 mm) wide shall be required.

(2) Where an automatic sprinkler system in accordance with NFPA 13D is installed and PV arrays occupy more than two-thirds of the total plan view roof area, a setback of not less 3 feet (914 mm) wide shall be required.

D 104.2.3 Distance to Plumbing Vents. Where PV panels are installed above a plumbing vent or stack, each vent pipe or stack shall extend through its flashing and shall terminate vertically not less than 6 inches (152 mm) above the roof nor less than 1 foot (305 mm) from a vertical surface, or shall be in accordance with the requirements of the Authority Having Jurisdiction.

D 104.2.3.1 Locations in Snow Regions. Where frost or snow closure is likely to occur in locations having a minimum design temperature below 0°F (-17.8°C), the installation of a solar panel shall be in accordance with one of the following:

(1) The solar panel shall be placed such that the plumbing vent does not terminate under the panel.

(2) The vent shall be diverted such that it is not under the solar panel. The change in direction shall be made inside the building not less than 1 foot (305 mm) below the roof in an insulated space and terminate not less than 10 inches (254 mm) above the roof and 6 inches (152 mm) from a solar panel, or in accordance with the Authority Having Jurisdiction.

D 104.3 Ground-Mounted Panel Systems. Plan review shall be required in accordance with the Authority Having Jurisdiction and the utility where a ground-mounted PV system is installed. See Section D 505.0 for a site plan sample of a residential ground-mounted PV-ESS.

Setback requirements shall not apply to ground-mounted and freestanding PV arrays. A clearance of not less than 10 feet (3048 mm) shall be required around ground-mounted PV arrays.

Installation and guarding of readily accessible PV source and output circuits, which operate at greater than 30 volts, shall be in accordance with Section 812.1 or NFPA 70.

D 105.0 Marking and Labeling.

D 105.1 General. Photovoltaic (PV) systems shall be marked. Materials used for markings shall be weather resistant and capable of withstanding continuous exposure to sunlight.

D 105.2 Main Service Disconnect. Markings shall be permitted to be placed within the main service disconnect. Where the main service disconnect is operable with the service panel closed, the marking shall be placed on the outside cover.

D 105.2.1 Marking Content and Format. Marking content and format for main service disconnects shall comply with the following:

(1) Marking content in accordance with NFPA 70

(2) Red background

(3) White lettering

(4) Minimum ⅜ of an inch (9.5 mm) letter height

(5) Capital letters

(6) Arial or similar font, non-bold

(7) Reflective, weather-resistant material (durable adhesive materials shall meet this requirement)

D 105.3 Marking for DC Conduit, Raceways, Enclosures, Cable Assemblies, and Junction Boxes. Markings shall be required on interior and exterior dc conduit, raceways, enclosures, cable assemblies, and junction boxes. Markings shall be placed on interior and exterior dc conduit, raceways, enclosures, and cable assemblies every 10 feet (3048 mm), at turns; on both sides of a penetration; and at dc combiner and junction boxes.

D 105.3.1 Marking Content and Format. Marking content and format for dc conduit, raceways, enclosures, cable assemblies, and junction boxes shall comply with the following:

(1) Marking content in accordance with NFPA 70

(2) Red background

(3) White lettering

(4) Minimum ⅜ of an inch (9.5 mm) letter height
(5) Capital letters
(6) Arial or similar font, non-bold
(7) Reflective, weather-resistant material (durable adhesive materials shall meet this requirement)

Part II – Size Optimization and Operation of PV-ESS.

D 201.0 General.
D 201.1 Applicability. Part II of this appendix may serve as a layout or roadmap of a predictive hierarchical control system for optimal sizing and design of PV-ESS. (See Figure D 201.1)

D 202.0 Inputs.
D 202.1 General. Data inputs for a predictive hierarchical control system may be determined in accordance with Section D 202.2 through Section D 202.6.

D 202.2 Objective Function. The objective function should represent the goals of the system and account for limitations or constraints to the project. Collaboration between the user and designer may be conducted to ensure the objectives and goals of the installed ESS are met.

Note: Unlike passive and renewable systems, ESS do not create power but instead shift the power use. Typically, ESS is utilized for load shifting (e.g., charging the batteries at night, and utilizing them during high load usages), peak shaving (e.g., trimming the high demand ‘spikes’ off of the utility meter usage), or for emergency battery backup.

D 202.3 Constraints. Constraints of the project may include, but are not limited to, the following:
(1) Financial limitations
(2) Physical limitations
(3) Design limitations for compliance with the Authority Having Jurisdiction

D 202.4 Microgrid System. The microgrid system should make considerations for all of the following:
(1) Existing loads,
(2) Expected loads,
(3) Other renewable systems used by the dwelling/building,
(4) Weather, and
(5) Irradiance.

D 202.5 High Level Planning Algorithm. The high level planning should utilize the learning-based global horizontal irradiance (GHI) prediction models and load predictions to find the best high level operation strategy. The strategy should update frequently, and the system should continue to adjust due to changing goals or restrictions in accordance with the low level planning algorithm in Section D 202.6.

D 202.6 Low Level Planning Algorithm. The low level planning should account for adjustments due to changing goals or restrictions to the system. Adjustments may be made to meet these goals, by the minute, by the hour, or as deemed necessary by the user. Considerations should be made for the initial design of the system to ensure system optimization. The low level planning algorithm should assist with commission of the ESS and ensure functioning meets the needs of the user.

Note: The low level planning algorithm may be adjusted either manually or through the use of software. For example, if the system was designed to meet the needs of peak shaving and the user was experiencing more rolling blackouts than expected, then the customer might opt to shift energy storage resources from peak shaving to the emergency backup.


D 301.0 General.
D 301.1 Applicability. The requirements for safe work practices during electrical installations shall be in accordance with Part III of this appendix, or NFPA 70E, whichever is more stringent.

D 302.0 Preventative Maintenance.
D 302.1 General. Maintenance on electrical equipment shall be completed by qualified persons and in accordance with the manufacturer’s instructions. The equipment owner shall be responsible for maintenance and documentation. A qualified person(s) shall be as defined in accordance with Chapter 8 or NFPA 70.

D 303.0 Arc Flash.
D 303.1 General. Arc flash risk assessment shall be in accordance with Section D 303.2. Calculations shall be determined in accordance with Section D 303.3. Training and audits shall be in accordance with Section D 303.4. Documentation shall be in accordance with Section D 303.5.

D 303.2 Risk Assessment. Arc flash risk assessment shall be completed prior to allowing a worker to perform tasks on energized equipment. Arc flash risk assessments shall be competed not less than once every five years to account for changes in the distribution system. In the event of a major modification or renovation, an updated arc flash risk assessment shall be conducted.

Note: The latest versions of NFPA 70E limit the use of shock protection approach boundary tables when determining arc flash boundaries and strongly encourage the use of engineering analysis, preferably conducted by a Professional Engineer.

D 303.3 Calculations. Arc flash calculations shall be determined using accurate short circuit calculations and protective device coordination data.

Note: Activities performed during short circuit and coordination studies include all of the following:
(1) Calculating the maximum momentary and interrupting current magnitudes,
(2) Comparing these available fault currents to protective device ratings, and
(3) Establishing trip settings for all types of protective devices.
**APPENDIX D**

**D 303.4 Training and Audits.** An arc flash training program along with a personal protective equipment (PPE) plan shall be provided by the employer based on analysis in accordance with Section D 303.2 and Section D 303.3. Individual workers shall undergo annual reviews and audits to ensure compliance with safety practices. Facilities shall audit their safety policies not less than once every three years.

**Note:** Audits help to identify any deficiencies or areas of non-compliance allowing the facility to make necessary revisions and bring all elements of the safety program up to code.

**D 303.5 Documentation.** Documentation shall include, but not be limited to, the following:

1. Arc flash analysis results
2. Meetings with employees to share hazard information
3. Worker training activities
4. Individual worker audicts
5. Maintenance activities
6. Safety policy audits

**Note:** Such documentation may help facilitate an investigation in the event of an arc flash related injury.

**D 304.0 Protection Scheme Design – Operational Assessment.**

**D 304.1 General.** A protection scheme design review and operational assessment of the electrical distribution system shall be completed.

**Note:** Such design and assessment may help identify and reduce potential electrical hazards. Based on the results of the review, experts may help develop mitigation strategies to alter...
the protection scheme and significantly reduce fault levels, arcing time, arc incident energy, and arc blast force.

D 305.0 Single-Line Diagrams.
D 305.1 General. A single-line diagram of the electrical system shall be provided. The line diagram shall be accurate, current, and in legible condition.
Note: This requirement may necessitate a comprehensive site review in order to develop or update existing diagrams. The resulting schematics are essential for documenting, troubleshooting, and communicating information about your power systems.

D 306.0 Labeling and Hazard Communication Plan.
D 306.1 General. Equipment owners shall be responsible for maintaining the condition and accuracy of labels. Where ac or dc equipment requires maintenance while energized, labels shall be provided and shall include the following:
(1) Results of the arc flash risk assessment
(2) Information for proper selection of PPE

Part IV – Smart Solar Monitoring Technology.

D 401.0 General.
D 401.1 Applicability. Part IV of this appendix applies to smart solar technology installed in tandem with solar PV systems to be utilized as an energy saving tool.
Note: Smart solar monitoring technology provides a means of influencing changes in energy conservation behaviors.

D 402.0 Smart Meters.
D 402.1 General. Smart meters should be installed in new or retro-fit solar PV systems. See Figure D 402.1 for an example of a smart meter.
Notes:
(1) Smart meters provide a means of measuring electrical consumption in real-time rather than only measuring total consumption. This facilitates more accurate measurements and better management of energy usage.
(2) Residential smart meters commonly come equipped with service switches which allow the utility to remotely enable power services.
(3) Some PV inverter equipment includes integrated smart meters with revenue grade metering.

D 403.0 Net Energy Metering.
D 403.1 General. Net energy metering may be used to measure the value of energy delivered minus the energy received over a specified period of time. See Figure D 403.1(1) through Figure D 403.1(3) for examples of NEM displays and a net energy flow diagram.
APPENDIX D

TABLE D 404.1
NEM DISPLAY ID’S

<table>
<thead>
<tr>
<th>DISPLAY ID</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>3</td>
<td>High Peak kW Del</td>
</tr>
<tr>
<td>4</td>
<td>High Peak kWh Del</td>
</tr>
<tr>
<td>5</td>
<td>High Peak kVArh Del</td>
</tr>
<tr>
<td>9</td>
<td>Low Peak KW Del</td>
</tr>
<tr>
<td>10</td>
<td>Low Peak KWH Del</td>
</tr>
<tr>
<td>11</td>
<td>Low Peak kVArh Del</td>
</tr>
<tr>
<td>15</td>
<td>Base KW Del</td>
</tr>
<tr>
<td>16</td>
<td>Base KWH Del</td>
</tr>
<tr>
<td>17</td>
<td>Base kVArh Del</td>
</tr>
<tr>
<td>21</td>
<td>High Peak KWH Rec</td>
</tr>
<tr>
<td>22</td>
<td>High Peak kVArh Rec</td>
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<tr>
<td>25</td>
<td>Low Peak KWH Rec</td>
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<tr>
<td>26</td>
<td>Low Peak kVArh Rec</td>
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<tr>
<td>29</td>
<td>Base KWH Rec</td>
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<tr>
<td>30</td>
<td>Base kVArh Rec</td>
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<tr>
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<td>43</td>
<td>Total KWH Rec</td>
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<td>Total kVArh Rec</td>
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<td>73</td>
<td>Base kWh Net</td>
</tr>
<tr>
<td>74</td>
<td>Total kWh Net</td>
</tr>
</tbody>
</table>

Note: Display ID’s 71 through 74 represent the Net kWh of the register on a meter.

FIGURE D 403.1(3)
NET ENERGY FLOW DIAGRAM
Part V – Site Plan Samples.

D 501.0 General.
D 501.1 Applicability. Part V of this appendix offers sample site plans for residential PV systems.

D 502.0 Site Plan Sample (PV).
D 502.1 General. The following is a site plan sample for a residential solar PV system. The sample plan consists of the following:

1. Cover sheet (See sheet number PV-1.0).
   - Vicinity map
   - Scope of work
   - General notes
   - Legend and abbreviations

2. Site plan (See sheet number PV-2.0).
   - Roof plan
   - Conduit mounting detail

3. Layout (See sheet number PV-3.0).
   - Module design criteria
     - Manufacturer/model number
     - Dimensions
     - Clamps
     - Maximum distributed load
     - Snow load
     - Wind speed
   - Module elevation detail
   - Roof type, height, and exposure
   - Roof edge zone
   - Mounting detail
   - Frame material and type
   - Maximum frame span
   - Maximum module overhang

4. Electrical (See sheet number PV-4.0).
   - Electrical line diagram
   - Conduit schedule
   - Module characteristics
   - Grounding detail
   - Notes to installer

5. Electrical calculations (See sheet number PV-4.1).

6. Signage (See sheet number PV-5.0).
D 503.0 Site Plan Sample (PV + EV Charging).

D 503.1 General. The following is a site plan sample for a residential solar PV system enabled with electrical vehicle (EV) charging. The sample plan consists of the following:

1. Site plan and vicinity map (See sheet number PV-1.0).
   a. Project description
   b. Site plan with roof plan
   c. House photo
   d. Vicinity map
   e. Legend

2. Roof plan and modules (See sheet number PV-2.0).
   a. Module type, dimensions, and weight
   b. Roof description
   c. Array and roof area calculations

3. Attachment detail (See sheet number PV-3.0).
   a. Project details
   b. Load assumptions
   c. System weight
   d. Roof information
   e. Span details
   f. Reaction forces

4. Electrical line diagram (See sheet number PV-4.0).

5. Wiring calculations (See sheet number PV-5.0).
   a. Conductor ampacity calculations – junction box to combiner box
   b. Conductor ampacity calculations – combiner box to main service panel
   c. Microinverter specifications
   d. Electrical notes

6. Placards (See sheet number PV-6.0).

7. Labeling plan (See sheet number PV-7.0).

8. Equipment specifications (See sheet number PV-8.0).
   a. AC electrical specifications
   b. DC electrical specifications
   c. Operation conditions and safety ratings
   d. Mechanical specifications
   e. Module dimensions

9. Stringing diagram (See sheet number PV-9.0).

10. Sticker layout (See sheet number PV-10.0).

11. Site safety plan (See sheet number PV-11.0).
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D 504.0 Site Plan Sample (PV-ESS with Whole Home Backup).

D 504.1 General. The following is a site plan sample for a residential solar PV system enabled with energy storage and whole home backup. The sample plan consists of the following:

1. Site plan and vicinity map (See sheet number PV-1.0).
   a) Project description
   b) Site plan with roof plan
   c) House photo
   d) Vicinity map
   e) Legend

2. Roof plan and modules (See sheet number PV-2.0).
   a) Module type, dimensions, and weight
   b) Roof description
   c) Array and roof area calculations
   d) Battery type, dimensions, and weight

3. Attachment detail (See sheet number PV-3.0).
   a) Project details
   b) Load assumptions
   c) System weight
   d) Roof information
   e) Span details
   f) Reaction forces

4. Electrical line diagram (See sheet number PV-4.0).

5. Wiring calculations (See sheet number PV-5.0).
   a) Conductor ampacity calculations – junction box to combiner box
   b) Conductor ampacity calculations – combiner box to main service panel
   c) Microinverter specifications
   d) Electrical notes

6. Placards (See sheet number PV-6.0).

7. Labeling plan (See sheet number PV-7.0).

8. Equipment specifications (See sheet number PV-8.0).
   a) AC electrical specifications
   b) DC electrical specifications
   c) Operation conditions and safety ratings
   d) Mechanical specifications
   e) Module dimensions

9. Stringing diagram (See sheet number PV-9.0).

10. Sticker layout (See sheet number PV-10.0).

11. Site safety plan (See sheet number PV-11.0).
### APPENDIX D

**Photovoltaic Module Specifications**

<table>
<thead>
<tr>
<th>Module Dimensions (Front, Rear, And Side Views)</th>
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<tbody>
<tr>
<td>Dimensions</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Module Area</td>
</tr>
<tr>
<td>Internal Bypass Choices</td>
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</table>

<table>
<thead>
<tr>
<th>Mechanical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9 x 1.7m</td>
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</table>

<table>
<thead>
<tr>
<th>Operation Conditions &amp; Safety Ratings</th>
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</thead>
<tbody>
<tr>
<td>Warranty</td>
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<tr>
<td>Wattage</td>
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<tr>
<td>Module Efficiency</td>
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<tr>
<td>Cell Efficiency</td>
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<tr>
<td>PTO/AC Ratio</td>
</tr>
<tr>
<td>MPP Rating</td>
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<tr>
<td>Max Temperature Coefficient</td>
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<table>
<thead>
<tr>
<th>DC Electrical Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (continuous)</td>
</tr>
<tr>
<td>Power (continuous)</td>
</tr>
<tr>
<td>Power (maximum available)</td>
</tr>
<tr>
<td>Power (maximum usable)</td>
</tr>
</tbody>
</table>

**Model No.**

**Manufacturer:** [Company Name]

---

**UL 790 Free Classification**

**Safety & Lighting Certifications**

**Rail Safety with Mounting System**

**Operating Temperature**
D 505.0 Site Plan Sample (Ground-Mounted PV-ESS with Whole Home Backup).

D 505.1 General. The following is a site plan sample for a ground mounted residential solar PV system enabled with energy storage and whole home backup. The sample plan consists of the following:

1. Site plan and vicinity map (See sheet number PV-1.0).
   - (a) Project description
   - (b) Site plan
   - (c) House photo
   - (d) Vicinity map
   - (e) Legend

2. Roof plan and modules (See sheet number PV-2.0).
   - (a) Project layout
   - (b) Battery type, dimensions, and weight
   - (c) Existing system

3. Electrical line diagram (See sheet number PV-3.0).

4. Placards (See sheet number PV-4.0).

5. Equipment Specifications
   - (a) Battery and backup specifications (See sheet number PV-5.0).
     - (i) Performance specifications
     - (ii) Compliance information
     - (iii) Mechanical specifications
     - (iv) Environmental specifications
     - (v) Dimensions
APPENDIX E
RECOMMENDED CONFIGURATIONS FOR MAINTAINING QUALITY OF HEAT TRANSFER FLUIDS IN CLOSED-LOOP HYDRONIC SYSTEMS

E 101.0 General.
E 101.1 Applicability. This appendix provides recommended configurations for both residential and non-residential closed-loop hydronic heating and cooling systems.
E 101.2 Purpose. The recommended configurations serve as a means of maintaining quality of heat transfer fluids over the life of the system and optimizing the life of system components.

E 102.0 Near Boiler Piping Schematics.
E 102.1 Systems with Chemical Additives. See Figure E 102.1(1) for a recommended near boiler piping schematic of a closed-loop hydronic system with chemical additives. The air separator is located at the optimal point within the system. See Figure E 102.1(2) for a recommended near boiler piping schematic of a closed-loop hydronic system utilizing glycol as the heat transfer fluid.
E 102.2 Systems without Chemical Additives. See Figure E 102.2 for a recommended configuration for a closed-loop hydronic system without chemical additives. The air separator is located at the optimal point within the system.

FIGURE E 102.1(1)
NEAR BOILER PIPING SCHEMATIC – CHEMICAL ADDITIVES

Note: This configuration is not applicable to hydronic systems containing antifreeze on the load side of the system, [e.g. snow and ice melt systems (SIMS)]
APPENDIX F
NET ZERO AND NET POSITIVE APPLICATIONS

F 101.0 General.

F 101.1 Applicability. The purpose of this appendix is to provide guidelines for achieving net zero energy and net positive energy buildings through the use of energy efficient equipment and renewable energy systems.

F 102.0 Definitions.

F 102.1 General. For the purposes of this appendix, the following definitions shall apply:

Energy Loading Order. A design pathway aligned with achieving net zero energy consumption through energy efficient strategies and measures.

Energy Star. A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. Energy Star is a voluntary program designed to identify and promote energy-efficient products and practices.

Net Zero Energy Building. A building with net zero energy consumption; the total annual amount of energy consumed by a building is equal to the amount of on-site renewable energy generated.

Renewable Energy Sources. Energy from solar, wind, biomass, or hydro, or extracted from hot fluid or steam heated within the earth.

F 103.0 General Regulations.

F 103.1 Installation. Systems covered by this appendix shall be installed in accordance with this code, other applicable codes, and the manufacturer’s installation and operating instructions.

F 103.1.1 Renewable Energy Systems. Renewable energy systems shall be designed and installed as follows:

1. Solar thermal systems in accordance with Chapter 5.
2. Geothermal energy systems in accordance with Chapter 7.
3. Solar photovoltaic systems in accordance with Chapter 8 and IAPMO IS 34.

F 103.1.2 Water Conservation. Water efficiency and conservation shall be in accordance with the Water Efficiency and Sanitation Standard (IAPMO/ANSI WE•Stand).

F 103.2 Qualifications. Where permits are required, the Authority Having Jurisdiction shall have the authority to require contractors, installers, or service technicians to demonstrate competency. Where determined by the Authority Having Jurisdiction, the contractor, installer, or service technician shall be licensed to perform such work.

F 104.0 Certification.

F 104.1 General. Net zero buildings shall be certified by one of the following agencies:

1. U.S. Green Building Council (USGBC);
2. International Living Future Institute (ILFI);
3. Department of Energy (DOE);
4. Earth Advantage; or
5. Other equivalent approved agencies.

F 105.0 Energy Loading Order.

F 105.1 General. New and retrofit construction of residential and commercial buildings shall be designed and installed in the following energy loading order:

1. Building envelope
   a. Reduction of infiltration
   b. Insulation
   c. Glazing of windows and doors
2. Water heating appliances in accordance with the Energy Star program.
3. Space heating
4. Lighting
5. Other appliances
6. Air-Conditioning
7. Renewable energy systems

F 106.0 Sustainable Practices.

F 106.1 General. This section covers provisions that promote sustainable practices by enhancing the design and construction of mechanical systems to result in a positive long-term environmental impact. (See Figure F 106.1.)

F 106.2 Use of Reclaimed (Recycled) and Onsite Treated Nonpotable Water for Cooling. Where approved for use by the water or wastewater utility and the Authority Having Jurisdiction, reclaimed (recycled), or onsite treated nonpotable water shall be permitted to be used for industrial and commercial cooling or air-conditioning.

F 106.3 Heating, Ventilation, and Air Conditioning Systems Commissioning. The provisions of this section apply to the commissioning of commercial and institutional HVAC systems.

F 106.3.1 Commissioning Requirements. HVAC commissioning shall be included in the design and construction processes of the project to verify compliance with this appendix and verify that the HVAC systems and components meet the owner’s project requirements.
Commissioning shall be performed in accordance with this appendix by personnel trained and certified in commissioning by a nationally recognized organization. Commissioning requirements shall include the following:

1. Owner’s project requirements.
2. Basis of design.
3. Commissioning measures shown in the construction documents.
5. Functional performance.
7. Post construction documentation and training.
8. Commissioning report.

HVAC systems and components covered by this appendix, as well as process equipment and controls, and renewable energy systems, shall be included in the scope of the commissioning requirements.

F 106.3.2 Owner’s Project Requirements (OPR). The performance goals and requirements of the HVAC system shall be documented before the design phase of the project begins. This documentation shall include not less than the following:

1. Environmental and sustainability goals.
2. Energy efficiency goals.
3. Indoor environmental quality requirements.
4. Equipment and systems performance goals.
5. Building occupant and operations and maintenance (O&M) personnel expectations.

F 106.3.3 Basis of Design (BOD). A written explanation of how the design of the HVAC system meets the owner’s project requirements shall be completed at the design phase of the building project and updated as necessary during the design and construction phases. The basis of design document shall cover not less than the following systems:

1. Heating, ventilation, air conditioning (HVAC) systems and controls.
2. Water heating systems.
3. Renewable energy systems.

F 106.3.4 Commissioning Plan. A commissioning plan shall be completed to document the approach of how the project will be commissioned and shall be started during the design phase of the building project. The commissioning plan shall include not less than the following:

1. General project information.
2. Commissioning goals.
3. Systems to be commissioned. Plans to test systems and components shall include at least the following information:
   a. A detailed explanation of the original design intent.
   b. Equipment and systems to be tested, including the extent of tests.
   c. Functions to be tested.
   d. Conditions under which the test shall be performed.
   e. Measurable criteria for acceptable performance.
4. Commissioning team information.
5. Commissioning process activities, schedules, and responsibilities. Plans for the completion of commissioning requirements listed in Section F 106.3.5 through Section F 106.5 shall be included.

F 106.3.5 Functional Performance Testing. Functional performance tests shall demonstrate the correct installation and operation of each component, system, and system-to-system interface in accordance with the approved plans and specifications. Functional performance testing reports shall contain information addressing each of the building components tested, the testing methods utilized, and readings and adjustments made.

F 106.4 Construction Documents. Details of commissioning acceptance requirements shall be incorporated into the construction documents, including information that describes the details of the functional tests to be performed. This information shall be permitted to be integrated into the specifications for testing and air balancing, energy management and control systems, and equipment startup procedures or commissioning. It is possible that the work will be performed by a combination of the test and balance (TAB) contractor, mechanical/electrical contractor, and the energy management control system (EMCS) contractor; so applicable roles and responsibilities shall be clearly called out.

Notes:
1. The delivered energy may consist of renewable and nonrenewable sources while only renewable energy is exported from the site boundary.
2. Renewable energy generation may be from bulk power systems with utility-scale solar, geothermal, hydro, and biomass facilities.
3. The dashed lines represent the site boundary.

FIGURE F 106.1
ENERGY TRANSFER FOR NET ZERO ENERGY PROJECTS

1,2,3
**F 106.5 Commissioning Tests.** Functional tests shall be performed on new equipment and systems installed in either new construction or retrofit applications in accordance with the mechanical code and the Authority Having Jurisdiction. The appropriate certificate of acceptance form along with each specific test shall be completed and submitted to the Authority Having Jurisdiction before a final occupancy permit can be granted.

**F 106.6 Minimum Equipment Efficiency Tables.** The minimum efficiency requirements for listed equipment shall comply with ASHRAE 90.1.
## USEFUL TABLES
### CONVERSION TABLES

**Note:** The information contained in these tables are not part of this American National Standard (ANS) and have not been processed in accordance with ANSI's requirements for an ANS. As such, these tables may contain material that has not been subjected to public review or a consensus process. In addition, they do not contain requirements necessary for conformance to the standard.

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### USEFUL TABLES

#### UNIT CONVERSIONS (continued)

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<td>Millimeters (mm)</td>
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<tr>
<td>Minutes (min)</td>
<td>2.908882 x 10^-4</td>
<td>Radians (rads)</td>
</tr>
<tr>
<td>Ounces/square inch (oz/in²)</td>
<td>43.94185</td>
<td>Kilograms/square meter (kg/m²)</td>
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<tr>
<td>Ounces/square feet (oz/ft²)</td>
<td>0.03051517</td>
<td>Kilograms/square meter (kg/m²)</td>
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<td>Ounces (oz)</td>
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<td>Grams (g)</td>
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<td>Ounces (oz)</td>
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<td>Kilograms (kg)</td>
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<td>Millimeters (mL)</td>
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<td>Pints</td>
<td>0.4731765</td>
<td>Liters (L)</td>
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<tr>
<td>Pound-force feet (lbf•ft)</td>
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<td>Newton meters (N•m)</td>
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<td>Pound-force inch (lbf•in)</td>
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<td>Newton meters (N•m)</td>
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<td>Pound-force per foot (lbf/ft)</td>
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<td>Newton meters (N•m)</td>
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<td>47.88026</td>
<td>Pascals (Pa)</td>
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<td>6.894757</td>
<td>Kilopascals (kPa)</td>
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<td>Pound-force per inch (lbf/in)</td>
<td>175.1268</td>
<td>Newton meters (N•m)</td>
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<td>Pounds/cubic inch (lb/in³)</td>
<td>2267990 x 10⁴</td>
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<td>Pounds/cubic yard (lb/yd³)</td>
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<td>Pounds (lb)</td>
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<td>Pounds/foot (lb/ft)</td>
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<td>Pounds/hour (lb/h)</td>
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<td>Kilograms/second (kg/s)</td>
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<td>Pounds/minute (lb/min)</td>
<td>7.559873 x 10³</td>
<td>Kilograms/second (kg/s)</td>
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<tr>
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<tr>
<td>Pounds/square inch (lb/in²)</td>
<td>703.1</td>
<td>Kilograms-force/square meter (kg/m²)</td>
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<tr>
<td>Pounds/square foot (lb/ft²)</td>
<td>4.882427</td>
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<td>Pounds-force (lbf)</td>
<td>4.448222</td>
<td>Newtons (N)</td>
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<tr>
<td>Pounds-force/square inch (psi)</td>
<td>0.06805</td>
<td>Atmosphere (standard) (atm)</td>
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<tr>
<td>Pounds-force/square inch (psi)</td>
<td>2.307</td>
<td>Feet of water (4°C)</td>
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<tr>
<td>Pounds-force/square inch (psi)</td>
<td>2.036</td>
<td>Inches of mercury (0°C)</td>
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<tr>
<td>Pounds-force/square inch (psi)</td>
<td>6.89476</td>
<td>Kilopascals (kPa)</td>
</tr>
<tr>
<td>Quarts (U.S. dry) (dry qt)</td>
<td>67.20</td>
<td>Cubic inches (in³)</td>
</tr>
<tr>
<td>Quarts (U.S. liquid) (liq qt)</td>
<td>57.75</td>
<td>Cubic inches (in³)</td>
</tr>
<tr>
<td>Quarts (liquid)</td>
<td>0.9463529</td>
<td>Liters (L)</td>
</tr>
<tr>
<td>Radians (rads)</td>
<td>57.30</td>
<td>Degrees (deg)</td>
</tr>
<tr>
<td>Seconds (s)</td>
<td>4.848137 x 10^-6</td>
<td>Radians (rads)</td>
</tr>
<tr>
<td>Square acre</td>
<td>0.404687</td>
<td>Square kilometers (km²)</td>
</tr>
<tr>
<td>Square feet (ft²)</td>
<td>144</td>
<td>Square inches (in²)</td>
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<tr>
<td>Square feet (ft²)</td>
<td>0.0929034</td>
<td>Square meters (m²)</td>
</tr>
</tbody>
</table>

**Useful Tables**
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<table>
<thead>
<tr>
<th>MULTIPLY</th>
<th>BY</th>
<th>TO OBTAIN</th>
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<tbody>
<tr>
<td>Square inches ((\text{in}^2))</td>
<td>(\times 645.16)</td>
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</tr>
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<td>Square meters ((\text{m}^2))</td>
<td>(\times 1550)</td>
<td>Square inches ((\text{in}^2))</td>
</tr>
<tr>
<td>Square miles ((\text{mi}^2))</td>
<td>(\times 640)</td>
<td>Acres</td>
</tr>
<tr>
<td>Square miles ((\text{mi}^2))</td>
<td>(\times 2.589988)</td>
<td>Square kilometers ((\text{km}^2))</td>
</tr>
<tr>
<td>Square millimeters ((\text{mm}^2))</td>
<td>(\times 1.55 \times 10^{-3})</td>
<td>Square inches ((\text{in}^2))</td>
</tr>
<tr>
<td>Square yards ((\text{yd}^2))</td>
<td>(\times 0.8361274)</td>
<td>Square meters ((\text{m}^2))</td>
</tr>
<tr>
<td>Temperature ((^\circ\text{C})) + 17.28</td>
<td>(\times 1.8)</td>
<td>Temperature ((^\circ\text{F}))</td>
</tr>
<tr>
<td>Temperature ((^\circ\text{F})) - 32</td>
<td>(\times \frac{5}{9})</td>
<td>Temperature ((^\circ\text{C}))</td>
</tr>
<tr>
<td>Ton-force (tonf) (2000 lbf)</td>
<td>(\times 8.896443)</td>
<td>Kilonewtons (kN)</td>
</tr>
<tr>
<td>Ton-force foot (tonf•\text{ft})</td>
<td>(\times 2.71342)</td>
<td>Kilonewton meters (kN•m)</td>
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<tr>
<td>Ton-force per square foot (tonf/\text{ft}^2)</td>
<td>(\times 95.7605)</td>
<td>Kilopascals (kPa)</td>
</tr>
<tr>
<td>Ton-force per square inch (tonf/\text{in}^2)</td>
<td>(\times 13.7895)</td>
<td>Megapascals (MPa)</td>
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<tr>
<td>Tons (metric)</td>
<td>(\times 1000)</td>
<td>Kilograms (kg)</td>
</tr>
<tr>
<td>Tons (long) (2240 lbs)</td>
<td>(\times 1016.047)</td>
<td>Kilograms (kg)</td>
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<tr>
<td>Tons (short)</td>
<td>(\times 2000)</td>
<td>Pounds (lbs)</td>
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<td>Water pressure (psi)</td>
<td>(\times 0.434)</td>
<td>Change in Pressure/foot elevation (psi/ft)</td>
</tr>
<tr>
<td>Water pressure (psi)</td>
<td>(\times 0.036)</td>
<td>Change in Pressure/inch elevation (psi/in)</td>
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<tr>
<td>Watts</td>
<td>(\times 3.4121)</td>
<td>British thermal units per hour (Btus/h)</td>
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<tr>
<td>Watts</td>
<td>(\times 1.341 \times 10^3)</td>
<td>Horsepower (hp)</td>
</tr>
<tr>
<td>Yards (y)</td>
<td>(\times 0.9144)</td>
<td>Meters (m)</td>
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</table>

### SI SYMBOLS AND PREFIXES

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<th>MULTIPLICATION FACTOR</th>
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<th>SYMBOL</th>
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<td>exa</td>
<td>E</td>
</tr>
<tr>
<td>(1 \times 10^{15})</td>
<td>peta</td>
<td>P</td>
</tr>
<tr>
<td>(1 \times 10^{12})</td>
<td>tera</td>
<td>T</td>
</tr>
<tr>
<td>(1 \times 10^{9})</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>(1 \times 10^{6})</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>(1 \times 10^{3})</td>
<td>kilo</td>
<td>k</td>
</tr>
<tr>
<td>(1 \times 10^{2})</td>
<td>hecto</td>
<td>h</td>
</tr>
<tr>
<td>(1 \times 10^{1})</td>
<td>deka</td>
<td>da</td>
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<td>(1 \times 10^{-1})</td>
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<td>(1 \times 10^{-2})</td>
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<td>c</td>
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<td>m</td>
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<td>(1 \times 10^{-6})</td>
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<td>n</td>
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<td>p</td>
</tr>
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<td>(1 \times 10^{-15})</td>
<td>femto</td>
<td>f</td>
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<tr>
<td>(1 \times 10^{-18})</td>
<td>atto</td>
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### AREAS AND CIRCUMFERENCES OF CIRCLES

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<th>Area</th>
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<td><strong>mm</strong></td>
<td><strong>Inches</strong></td>
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<td>10</td>
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<td>15</td>
<td>1.57</td>
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<td>20</td>
<td>2.36</td>
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<tr>
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<td>25</td>
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<td>32</td>
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<td>40</td>
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<td>50</td>
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</tr>
<tr>
<td>10</td>
<td>250</td>
<td>31.42</td>
</tr>
</tbody>
</table>

**Equal Peripheries**

\[
\begin{align*}
S &= 0.7854 D \\
D &= 1.2732 S
\end{align*}
\]

**Equal Areas**

Area of square (S') = 
\[1.2732 \times \text{area of circle}\]

Area of square (S) = 
\[0.6366 \times \text{area of circle}\]

\[
\begin{align*}
C &= \pi D = 2 \pi R \\
C &= 3.5446 \ \text{varea} \\
D &= 0.3183 \ C = 2R \\
D &= 1.1283 \ \text{varea} \\
\text{Area} &= \pi R^2 = 0.7854 D^2 \\
\text{Area} &= 0.07958 \ C^2 = \frac{\pi D^2}{4}
\end{align*}
\]
SYMBOLS

The following is a list of symbols commonly utilized in solar energy applications and are provided herein for the convenience of the users of this code. This list is based on ASHRAE 93.

\[ a, b, a', b' = \text{constants used in incident angle modifier equation, dimensionless} \]
\[ A = \text{cross-sectional area, ft}^2 (m^2) \]
\[ A_a = \text{transparent frontal area for a nonconcentrating collector or the aperture area of a concentrating collector, ft}^2 (m^2) \]
\[ A_g = \text{gross collector area, ft}^2 (m^2) \]
\[ A_r = \text{absorbing area of a nonconcentrating collector or the receiving area of a concentrating collector, ft}^2 (m^2) \]
\[ b_o = \text{constant used in incident angle modifier equation, dimensionless} \]
\[ B = \text{effective angle for determining the equation of time, degrees} \]
\[ C_A = \text{effective heat capacity of the solar collector, Btu/(lbm•°F) [J/(kg•K)]} \]
\[ c_p = \text{specific heat of the heat transfer fluid, Btu/(lbm•°F) [J/(kg•K)]} \]
\[ E = \text{equation of time, minutes} \]
\[ E_{\lambda i} = \text{solar spectral irradiance averaged over } \Delta \lambda \text{ centered at } \lambda_i \text{ at air mass } 1.5 \text{ W/(m}^2\cdot\mu\text{m)} \]
\[ F' = \text{absorber plate efficiency factor, dimensionless} \]
\[ F_R = \text{solar collector heat removal factor, dimensionless} \]
\[ G = \text{direct solar irradiance, Btu/(ft}^2\cdot\text{h}) (W/m}^2\) \]
\[ G_{bp} = \text{direct solar irradiance component in the aperture plane, Btu/(ft}^2\cdot\text{h}) (W/m}^2\) \]
\[ G_{DN} = \text{diffuse solar irradiance incident upon the aperture plane of collector, Btu/(ft}^2\cdot\text{h}) (W/m}^2\) \]
\[ G_{Sc} = \text{global solar irradiance incident upon the aperture plane of collector, Btu/(ft}^2\cdot\text{h}) (W/m}^2\) \]
\[ G_t = \text{global solar irradiance, 429.2 Btu/(ft}^2\cdot\text{h}) (1353 W/m}^2\) \]
\[ h_a = \text{enthalpy of the ambient air-water vapor mixture, Btu/lbm (J/kg)} \]
\[ h_{f,e} = \text{enthalpy of the air-water vapor mixture at the exit of the air collector, Btu/lbm (J/kg)} \]
\[ h_{f,i} = \text{enthalpy of the air-water vapor mixture at the inlet of the air collector, Btu/lbm (J/kg)} \]
\[ h_L = \text{enthalpy of the leaking air-water vapor mixture, Btu/lbm (J/kg)} \]
\[ K = \text{factor defined by ASHRAE 93, dimensionless} \]
\[ K_a = \text{incident angle modifier, dimensionless} \]
\[ K_d = \text{diffuse irradiance incident angle modifier, dimensionless} \]
\[ K_I = \text{incident angle modifier for biaxial collector, dimensionless} \]
\[ K_2 = \text{incident angle modifier for biaxial collector, dimensionless} \]
\[ L_{loc} = \text{longitude, degrees west} \]
\[ L_{st} = \text{standard meridian for local time zone, degrees west} \]
\[ LST = \text{local standard time, decimal hours} \]
\[ LSTM = \text{local standard time meridian, degrees west} \]
\[ AST = \text{apparent solar time, decimal hours} \]
\[ m = \text{air mass, dimensionless} \]
\[ m = \text{mass flow rate of the heat-transfer fluid, lbm/h (kg/s)} \]
\[ m_e = \text{downstream air mass flow rate, lbm/h (kg/s)} \]
\[ m_i = \text{upstream air mass flow rate, lbm/h (kg/s)} \]
\[ m_L = \text{leakage air mass flow rate, lbm/h (kg/s)} \]
\[ n = \text{day of year, beginning with January } 1 = 1 \]
\[ \eta_r = \text{collector efficiency based upon absorber area and inlet temperature,}\% \]
\[ p = \text{optical property, dimensionless} \]
\[ P_{f,e} = \text{static pressure of heat-transfer fluid at the outlet to the solar collector, lbf/in}^2 (Pa) \]
\[ P_{f,i} = \text{static pressure of heat-transfer fluid at the inlet to the solar collector, lbf/in}^2 (Pa) \]
\[ \Delta P = \text{pressure drop across the collector, lbf/in}^2 (Pa) \]
\[ Q_{mi} = \text{measured volumetric airflow rate at the collector inlet, ft}^3/\text{min (m}^3/\text{s}) \]
\[ Q_s = \text{airflow rate corrected to standard conditions, ft}^3/\text{min (m}^3/\text{s}) \]
\[ q_u = \text{rate of useful energy extraction from the collector, Btu/h (W)} \]
\[ t_a = \text{ambient air temperature, °F (°C)} \]
\[ t_f = \text{average fluid temperature, °F (°C)} \]
\[ t_{f,e} = \text{temperature of the heat-transfer fluid leaving the collector, °F (°C)} \]
\[ t_{f,e,T} = \text{temperature of the heat-transfer fluid leaving the collector at a specified time, °F (°C)} \]
\[ t_{f,e,initial} = \text{temperature leaving the collector at the beginning of time constant test period, °F (°C)} \]
\[ t_{f,i} = \text{temperature of the heat-transfer fluid entering the collector, °F (°C)} \]
\[ t_p = \text{average temperature of the absorbing surface for a nonconcentrating collector, °F (°C)} \]
\( t_r \) = average temperature of the absorbing surface for a concentrating collector, °F (°C)

\( \bar{i} \) = effective temperature defined by ASHRAE 93, °F (°C)

\( t_{HHL} \) = effective temperature for a given header heat loss test flow rate, °F (°C)

\( T \) = time, decimal hours or seconds

\( T_1, T_2 \) = time at the beginning and end of a test period, decimal hours or seconds

\( \Delta t \) = temperature difference, °F (°C)

\( \Delta t_{ss} \) = temperature difference, of inlet and outlet transfer fluid at steady state, °F (°C)

\( U_L \) = solar collector heat-transfer loss coefficient, Btu/(h•ft²•F) [W/(m²•K)]

\( W_n \) = humidity ratio at the nozzle, lbm H₂O/lbm dry air (kg H₂O/kg dry air)

\( \alpha \) = absorptance of the collector absorber surface for solar radiation, dimensionless

\( \gamma \) = fraction of specularly reflected radiation from the reflector or refracted radiation that is intercepted by the solar collector receiving area, dimensionless

\( \theta \) = angle of incidence between director solar rays and the normal, to the collector surface or to the aperture, degrees

\( \beta \) = solar altitude angle, degrees

\( \phi \) = solar azimuth angle, degrees

\( \eta_g \) = collector efficiency based upon gross collector area and inlet temperature, percent

\( \lambda \) = wavelength, μm

\( \lambda_i \) = specific wavelength, μm

\( \Delta \lambda_i \) = wavelength interval, μm

\( \rho \) = reflectance of a reflecting surface for solar radiation, dimensionless

\( \rho_{\lambda} \) = spectral reflectance of a reflecting surface for solar energy, dimensionless

\( \tau \) = transmittance of the solar collector cover plate, dimensionless

\( (\tau\alpha)_e \) = effective transmittance-absorptance product, dimensionless

\( (\tau\alpha)_{e,n} \) = effective transmittance-absorptance product at normal incidence, dimensionless

\( \Sigma \) = collector tilt from the horizontal, degrees
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