2018
Report on Proposals

The Mechanical Technical Committee
Report on Proposals for Public Review and Comment
Information on IAPMO Codes and Standards Development

1. Applicable Regulations. The primary rules governing the processing of the Uniform Plumbing Code and Uniform Mechanical Code are the IAPMO Regulations Governing Committee Projects (RGCP). Other applicable rules include Bylaws, Assembly Consideration Session Rules, Technical Meeting Convention Rules, Guide for the Conduct of Participants in the IAPMO Codes and Standards Development Process, and the Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council. 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.

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 and Technical Correlating Committee (if any) consisting of the Report on Proposals (ROP), as modified by the Report on Comments (ROC), published by the Association (see 1-4 of RGCP).

3. Report on Proposals (ROP). The ROP is defined as “a report to the Association on the actions taken by Technical Committees and/or Technical Correlating Committees, accompanied by a ballot statement and one or more proposals on text for a new Document or to amend an existing Document” (see 1-4 of RGCP). The ROP and the ROC together comprise the Technical Committee Report. Anyone who does not pursue an issue as a proposed amendment of the Association Meeting will be considered as having their objection resolved.

4. Assembly Comment. The Assembly Consideration Session, held during the second year of the code development cycle, will be held during IAPMO’s annual conference from September 30 - October 4, 2018, in Philadelphia, Pennsylvania. The Assembly Consideration Session is scheduled for October 2, 2018. Anyone in the Assembly who objects to an action of the Technical Committee, as published in the ROP, may make a motion in accordance with Section 4-4.3.1.2 of the RGCP and, if such motion is sustained by majority vote, both the TC action established by a letter ballot and the Assembly’s action, which shall be considered as a comment in accordance with Section 4-4.3.1, shall be included in the ROC.

5. Report on Comments (ROC). The ROC is defined as “a report to the Association on the actions taken by Technical Committees and/or Technical Correlating Committees accompanied by a ballot statement and one or more comments resulting from public review of the Report on Proposals (ROP)” (see 1-4 of RGCP). 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 4-5.4(c) of the RGCP, as a proposed amendment of the Association Meeting will be considered as having their objection resolved.

6. Association Amendments. The Technical Committee Reports, consisting of the ROP and ROC, will be presented at the Association Technical Meeting Convention for action. This meeting, held during the final year of the code development cycle, will be held during IAPMO’s annual conference from September 22 - 26, 2019, in Reno, Nevada. Amending motions made to the Technical Committee Reports may be made only at the Association Technical Meeting Convention in accordance with 4-5 and other applicable sections of the RGCP. Amending motions may be made in person or by a designated representative in accordance with Section 4-5.4(c) of the RGCP. Objections are deemed to be resolved if not pursued at this level.

7. Council Appeals. Anyone can appeal to the Standards Council 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 Council. Such appeals must be in written form and filed with the Secretary of the Standards Council (see 1-6 of RGCP). Time constraints for filing an appeal must be in accordance with 1-6.2 of the RGCP. Objections are deemed to be resolved if not pursued at this level.

8. Document Issuance. The Standards Council is the issuer of the Uniform Plumbing Code and Uniform Mechanical Code. The Council acts on the issuance of a Document within sixty days from the date of the recommendation from the Association Technical Meeting Convention, unless this period is extended by the Council (see 4-7 of RGCP).

9. Petitions to the Board of Directors. The Standards Council has been delegated the responsibility for the administration of the codes and standards development process and the issuance of documents. However, where extraordinary circumstances requiring the intervention of the Board of Directors exist, the Board of Directors may take any action necessary to fulfill its obligations to preserve the integrity of the IAPMO codes and standards development process. The rules for petitioning the Board of Directors can be found in the Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council and in 1-7 of the RGCP.
To: IAPMO Members and Other Interested Parties

Date: August 2018

Enclosed is your 2018 Report on Proposals (ROP). These proposals were presented to the Mechanical Technical Committee who met in Ontario, California on May 15 - 16, 2018.

At the Annual Education and Business Conference, which will be held September 30 – October 4, 2018, in Philadelphia, Pennsylvania, IAPMO members and others attending the conference will have the opportunity to discuss and debate these proposals during the Assembly Consideration Session.

All comments for consideration by the Technical Committee should be submitted to IAPMO by January 3, 2019.

On April 29 – May 2, 2019, the Technical Committee will consider all of the comments received in response to the actions contained within the ROP and will vote on whether to modify any of their previous actions.

Thereafter, from September 22 – 26, 2019, IAPMO will be holding its 90th Annual Education and Business Conference in Reno, Nevada. The IAPMO voting membership present at that conference will then vote on the actions taken by the Technical Committee during the Technical Meeting Convention. Please visit the IAPMO web site at www.iapmo.org for more information on the consensus code development process and timeline.

Following the ROP is a preprint of the Uniform Mechanical Code, as it would appear in the event that all of the proposals accepted by the Mechanical Technical Committee in May 2018 are ultimately approved for inclusion in the final version of the 2021 edition of the Uniform Mechanical Code. This preprint 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 2021 Uniform Mechanical Code. Specific authorization from IAPMO is required for republication or quotation.
## MECHANICAL TECHNICAL COMMITTEE
(as of 05/24/2018)

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<tr>
<th>NAME</th>
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<th>CLASSIFICATION</th>
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<tr>
<td>Harvey Kreitenberg, Chair</td>
<td>Harvey Kreitenberg &amp; Associates</td>
<td>Special Expert</td>
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<tr>
<td>Michael Hyde</td>
<td>State of Idaho-Division of Building &amp; Safety</td>
<td>Enforcing Authority</td>
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<tr>
<td>Shawn Hargis, Principal</td>
<td>City of Los Angeles Department of Building &amp; Safety</td>
<td>Enforcing Authority</td>
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<td>Kevin Brown, Alternate</td>
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<tr>
<td>Bob Adler, Principal</td>
<td>City of San Jose</td>
<td>Enforcing Authority</td>
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<tr>
<td>David Ledda, Alternate</td>
<td>City/County of San Francisco</td>
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<td>DJ Nunez*</td>
<td>IAPMO</td>
<td>Enforcing Authority</td>
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<td>John Heine, Principal</td>
<td>Heine Plumbing &amp; Heating</td>
<td>Installer/Maintainer</td>
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<td>Chuck White, Alternate</td>
<td>Plumbing Heating Cooling Contractors (PHCC)</td>
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<td>Sarah Aguilar</td>
<td>Ciari Plumbing &amp; Heating</td>
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<td>Dave Mann, Principal</td>
<td>CA State Pipe Trades</td>
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<td>Robert Sewell, Alternate</td>
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<td>David Dias</td>
<td>Sheet Metal Workers Local 104</td>
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<td>Randy Young</td>
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<td>Richard Benkowski, Principal</td>
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<td>Chris Van Rite, Principal</td>
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<td>Micah Dawson, Alternate</td>
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<td>Richard Church, Principal</td>
<td>Plastic Pipe &amp; Fittings Association (PPFA)</td>
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<td>Laura Moreno, Principal</td>
<td>National Fire Protection Association (NFPA)</td>
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<td>Tim Orris, Principal</td>
<td>Air Movement and Control Association International (AMCA)</td>
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<td>Phil Trafton</td>
<td>American Society of Heating, Refrigerating &amp; Air-Conditioning Engineers (ASHRAE)</td>
<td>Research/Standards/Test Lab</td>
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<td>April Trafton</td>
<td>Donald Dickerson &amp; Associates</td>
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<td>Donald Cary Smith</td>
<td>Sound Geothermal Corporation</td>
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<td>Jay Egg</td>
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<td>Phil Ribbs</td>
<td>PHR Consultants</td>
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<td>David Delaquila</td>
<td>National Propane Gas Association</td>
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<td>DJ Berger</td>
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<tr>
<td>Don Taylor</td>
<td>Self</td>
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<tr>
<td>Zalmie Hussein, Staff Liaison</td>
<td>IAPMO Staff</td>
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Total Voting Members: 26
Total Non-Voting Members: 2

The above listed TC Members are in order of classification (see far right column).
Patent Policy. IAPMO’s patent policy is to adhere fully to the ANSI patent policy. Every proponent of a code change proposal should familiarize him or herself with the ANSI patent policy which is available in its entirety at www.ansi.org/essentialrequirements. Upon receipt of a notice of an essential patent claim, IAPMO will coordinate with the claimant to ensure collection of the assurance(s) required by IAPMO’s adherence to the ANSI patent policy before the proposal that includes an essential patent claim is introduced into the code development process.
INSTRUCTIONS FOR SUBMITTING COMMENTS

PLEASE READ CAREFULLY

1. Check the appropriate box to indicate whether this comment recommends adding new text, revising existing text, or delete text without substitution (see examples below).
2. Enter the appropriate comment on proposal item number that the proposed text applies to.
3. In the space identified as “Proposed Text” indicate the exact wording you propose as new or revised text or the text you propose to be deleted.
4. In the space titled, “Statement of Problem and Substantiation/Resolution,” state the problem that will be resolved by your recommendation and give the specific reason for your comment.
5. Where referencing a standard in your comment, such standard needs to be submitted. Please provide two hard copies or one electronic copy with your comment. Please note that if the standard is not received by the closing date, your comment is considered incomplete and will not be processed.
6. Where additional supplementary materials such as tests, research papers, or other documents, need to be submitted, please provide supporting material electronically. Please note that if supporting material is not received by the closing date, it will not be accepted for review by the Technical Committee.
7. Check the box for copyright assignment. Please note if you are not the author of this comment (this text is copied from another source) please do not submit the proposed change. The author of the comment must give copyright assignment (which is the submitter’s own idea based on or as a result of research, experience and is not copied from another source).

Note: Content of Comments shall be in accordance with Section 4-4.5 of the IAPMO Regulations Governing Committee Projects of the UPC and UMC. Failure to comply with the above requirements will result in the comment not being processed. For further information on the standards process, please contact Code Development at 909-472-4111. For technical assistance, please call 909-230-5535 or 909-218-8122 or email alma.ramos@iapmo.org.

Please support IAPMO’s green initiative to remain paper free by providing the Proposed Monographs, Report on Proposals and Report on Comments in digital Adobe PDF. Note printed copies of the above referenced documents will not be available at the hearings.

Examples for applying charging statement for adding text, deleting text and revising text

Add new text as follows (applies only when adding a new section or all new text):
Water Service. Piping from the water main or source of water supply to the water distribution piping of the building or premises served irrespective of the water meter location.

Revise text as follows (applies when revising an existing section by deleting text, adding text or both as follows):
Building Supply. The pipe carrying potable water from the water meter or other source of water supply to the building or other point of use or distribution on the lot. Building supply shall also mean water service. Piping from the water main or source of water supply to the water distribution piping of the building or premises served irrespective of the water meter location.

Delete text without substitution (applies when deleting an entire section, table or both as follows):
302.0 Iron Pipe Size (IPS) Pipe. Iron, steel, brass and copper pipe shall be standard weight iron pipe size (IPS) pipe.
306.1 It shall be unlawful for any person to deposit, by any means whatsoever, into any plumbing fixture, floor drain, interceptor, sump, receptor, or device, which is connected to any drainage system, public sewer, private sewer, septic tank, or cesspool, any ashes; cinders; solids; rags; inflammable, poisonous, or explosive liquids or gas; oils; grease; or any other thing whatsoever that would, or could, cause damage to the drainage system or public sewer.
Assembly Consideration Session Rules

Adopted by the IAPMO Board of Directors on July 9, 2007 and approved by the Standards Council on June 19, 2007.

The Assembly Consideration Session is an important step in developing a complete record to assist the Standards Council in determining the degree of consensus achieved. These Rules, or any part of same, may not be suspended. The transaction of business at the Assembly Consideration Session shall be governed, in order of precedence, first by the Regulations Governing Committee Projects (see especially section 4-4.3.1.1), second by these Rules, and third by Robert’s Rules of Order Revised.

1. **Meetings.** The Secretary of the Standards Council shall develop and publish in advance, an agenda for each Assembly Consideration Session. At the discretion of the Secretary, the meeting may take place in a single session or may be divided into more than one session. All items on the agenda scheduled for consideration at a session shall be completed before the adjournment of that session.

2. **Adjournment.** Adjournment of each session shall take place only upon completion of the scheduled agenda.

3. **Recess.** A session may be recessed at any time at the discretion of the Chair. A motion to recess shall be allowed at the discretion of the Chair.

4. **Question of Privilege.** Ruled on by the Chair.

5. **Call for Orders of the Day.** Any change to the published agenda is to be announced by the Chair at the commencement of the session.

6. **Lay on the Table.** Not allowed.

7. **Previous Question.** Requires a two-thirds vote of those present. For informational purposes prior to the vote, the Chair has the authority to ask if there is anyone who wishes to speak, who has not spoken, and who has something new to add. A successful motion of the previous question will close debate on the pending motion and bring it to an immediate vote.

8. **Limit or Extend Debate.** Each speaker is allowed ten minutes to present their arguments.

9. **Postpone.** Allowed.

10. **Commit or Refer.** Not allowed.

11. **Motions.** See Regulations Governing Committee Projects at section 4-4.3.1.1 and 4-4.3.1.2.

12. **Postpone Indefinitely.** Not allowed.
13. Voting on Motions. Except as otherwise provided in these rules, the vote on motions shall be taken by a show of hands. If the Chair is uncertain of the result of the vote, he or she can order a counting of the vote. A successful main motion requires a majority vote of those present.


15. Appeal. Decisions of the Chair can be appealed except as otherwise prohibited by these rules. The proper venue for appeal of these rules is by an appeal filed with the Standards Council.


17. Division of Question. Allowable at the discretion of the Chair.

18. Division of Assembly. Not allowed.

19. Parliamentary Inquiry or Point of Information. Allowed.

20. Withdraw Motion. A motion can be withdrawn only by a majority vote of the members assembled.

21. Take from the Table. Not allowed.

22. Visual Aids and Physical Simulations. Visual aids and physical simulations of any kind are prohibited. Only verbal presentations are allowed.

23. Distribution of Materials. All materials distributed within the Association Technical Meeting room shall have prior approval by the secretary of the Standards Council. Only IAPMO staff shall be permitted to distribute such materials.

24. Reconsider, Rescind, or Amend Something Previously Adopted. Applicable only within the period of discussion of the specific document and prior to the final vote.
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**Task Group Reports**
Factory-Made Air Duct Task Group Report

**Technical Correlating Committee Report**

**2018 Uniform Mechanical Code Preprint**

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International Association of Plumbing and Mechanical Officials
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Item #: 001

UMC 2021  Section: 102.3

SUBMITTER: Ronald George, CPD, President
Plumb-Tech Design & Consulting Services LLC

RECOMMENDATION:
Revise text

102.3 Applicability.

102.3 Maintenance. Mechanical systems, materials, and appurtenances, both existing and new, of a premise under the Authority Having Jurisdiction shall be maintained in operating condition. Devices, equipment or safeguards required by this code shall be maintained in accordance with the manufacturer’s maintenance instructions so that a hazard is not created code edition under which installed.

The owner or the owner’s designated agent shall be responsible for maintenance of mechanical systems. To determine compliance with this subsection, the Authority Having Jurisdiction shall be permitted to cause a mechanical system to be reinspected.

SUBSTANTIATION:
Many hazards are created that are associated with poor maintenance. Such hazard include, but are not limited to: 1. Hot water temperatures maintained too low causing Legionella bacteria growth along with many other micro-organisms in water systems. 2. Scald hazards associated with water temperatures delivered from fixtures hotter than the temperatures allowed in Chapter four. 3. Backflow hazards associated with maintenance operations (chemical dispenser connections to mop sink faucets, etc.) Carbon Monoxide hazards associated with improper maintenance of water heaters, etc.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change does not add clarity to the code language. Furthermore, the proposed text creates confusion and undue burden on maintenance personnel.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 26
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 mechanical 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 mechanical system installations shall comply with the provisions for new construction. Additions, alterations, or repairs or replacement of equipment in an existing system shall not create a hazard of any kind elsewhere in the system. Any unless such deviations are found to be necessary and are first shall be approved by the Authority Having Jurisdiction.

SUBSTANTIATION:
It is common to find that a water heater or temperature actuated mixing valve maintenance or replacement work contributes to a scald incident where someone is seriously injured or dies from scald injuries. This code change proposal is intended to addresses this issue. If a water heater or a temperature actuated mixing valve is repaired or replaced and the building has existing, non-code compliant fixtures, (shower or tub filler valves), a serious scald hazard can be created if the new equipment has a higher temperature outlet. The Water heater thermostat in tank type heaters should not be used for temperature control, because the thermostat are simply burner ON and burner OFF controls with the sensor at the bottom of the water heater and they are not designed for sensing or controlling hot water temperatures at the water heater outlet temperature control. This code change will require checking of hot water temperatures after alterations to a hot water system including adjustment, repair or replacement of a water heater, temperature actuated mixing valve or other component in a system that can create or increase a scald hazard where one may not have been present before the work. This code change proposal will require checking the fixtures for temperature limit stop adjustments simply adjusting the temperature on existing temperature activated mixing valves or adding a temperature actuated mixing valve or some other means to address the hazard other than the thermostat on the water heater. ASSE is currently working on this issue as a white paper because it is known that there are many scald incidents associated with water heater and associated hot water system work. This should also be part of an awareness and continuing education training curriculum for the trades.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is unenforceable and similar provisions are already addressed within the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
CHAPTER 2
DEFINITIONS

205.0 – C –

Conditioned Space. An area, room, or space normally occupied and being heated or cooled for human habitation comfort by any equipment.

SUBSTANTIATION:
The beginning of the sentence already explains it is a room normally occupied, the space or room is ultimately being conditioned for human comfort, makes this definition easier to read.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
CHAPTER 2
DEFINITIONS

205.0 – C –

Cooling System. All of the equipment, ducts and components, including refrigeration, intended or installed for the purpose of cooling air by mechanical means and discharging such air into any room or conditioned space. This definition shall not include an evaporative cooler.

SUBSTANTIATION:
Adding "ducts and components" clearly helps to identify the cooling system in its entirety.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 005
UMC 2021  Section: 206.0

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

CHAPTER 2
DEFINITIONS

205.0  – C –

Combination Fire and Smoke Damper. A device that meets both the fire damper and smoke damper requirements. [NFPA 5000:3.3.139.2]

206.0  – D –

Damper. A valve or plate for controlling draft or the flow of gases, including air. [NFPA 211:3.3.52]

Combination Fire-Smoke Damper. An automatic-closing metal assembly consisting of one or more louvers, blades, slats, or vanes that closes upon detection of heat or smoke as to restrict the passage of heat and smoke and is listed to the applicable recognized standard.

SUBSTANTIATION:
To clearly define the materials used to construct and to clearly define it can be used in both fire control and smoke control.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
Amend proposal as follows:

206.0  – D –

Damper. A valve or plate for controlling draft or the flow of gases, including air. [NFPA 211:3.3.52]

Combination Fire-Smoke Damper. An automatic-closing metal assembly consisting of one or more louvers, blades, slats, or vanes that closes upon detection of heat or smoke as to restrict the passage of heat and smoke and is listed to the applicable recognized standard.

COMMITTEE STATEMENT:
The definition is being modified as it contains specific requirements which are not in accordance with the Manual of Style.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS:  AFFIRMATIVE: 26
Proposals
Edit Proposal
Item #: 006
UMC 2021  Section: 206.0

SUBMITTER: Phil Pettit
Control Air Conditioning Corporation

RECOMMENDATION:
Revise text

CHAPTER 2
DEFINITIONS

206.0  – D –

Duct. A tube or conduit passageway for transmission of air, fumes, vapors, or dust. 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.

SUBSTANTIATION:
The term “passageway” is consistent with the language found in the definition of “Duct System” and clearly describes the function and purpose of a duct, more so than the term “conduit”.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change to the term “passageway” is vague and creates confusion.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS:  AFFIRMATIVE: 26
Item #: 007

UMC 2021  Section: 207.0

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

CHAPTER 2
DEFINITIONS

207.0  – E –

Emergency Alarm System. A system intended to provide the indication notification and warning of abnormal conditions and summon appropriate aid.

SUBSTANTIATION:
Removing "the indication" and adding "notification" makes this easier to read.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 008
UMC 2021 Section: 210.0

SUBMITTER: Reinhard Hanselka
Menlo Park Fire Protection District
Rep: Consultant To District

RECOMMENDATION:
Revise text

CHAPTER 2
DEFINITIONS

210.0 – H –

HPM Storage Room. A room used for the storage or dispensing of hazardous production material (HPM) and that is classified as a Group H, Division 1, or Division 2, Division 3, or Division 4 Occupancy.

SUBSTANTIATION:
This is an update to the new potential Occupancies in the current Building and fire Codes.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
ITEM #: 009

UMC 2021 Section: 212.0

SUBMITTER: Mark Fasel
Viega LLC

RECOMMENDATION: Revise text

CHAPTER 2
DEFINITIONS

212.0 – J –

Joint, Press-Connect. A permanent mechanical joint consisting of an elastomeric seal or an elastomeric seal and corrosion-resistant grip or bite ring. The joint is made with a pressing tool and jaw or ring approved by the fitting manufacturer.

SUBSTANTIATION:
We have discovered that the mechanical attaching grip "or bite" ring is referred to as a grip ring by some manufacturer’s and a bite ring by others. The proposed addition of the words "or bite" are for clarification that a Press-Connect joint may incorporate a grip or a bite ring in the design. These terms are usually found in the dimensional drawings of the fittings. This revision will provide clarification for the Building Official and Installer so there are no misunderstandings on what may be considered a Press-Connect Joint.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is unnecessary and does not strengthen the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 6

EXPLANATION OF AFFIRMATIVE:

MANN: There was no technical justification provided for the addition of "bite."

EXPLANATION OF NEGATIVE:

CUDAHY: I believe this language was accepted in another model code.

FEEHAN: The term bite is used in the industry and does not change the code, but gives more information to the end user.

HOWARD: The additional language does provide clarification. The Committee rationale should not always be based on if it strengthens the code, but rather does it provide a benefit to the end users.

KOERGER: I do not see a problem with adding "bite ring" reference for clarification.

MACNEVIN: No technical objection to adding "bite."

A. TRAFTON: The term bite is used in submittals and in standard industry language.
Proposals

Edit Proposal

Item #: 010

UMC 2021  Section: Chapter 2: 205.0 - 224.0

SUBMITTER: IAPMO Staff - Update Extracts
  NFPA 54 Extract Update

RECOMMENDATION:
  Revise text

CHAPTER 2
DEFINITIONS

205.0  – C –

Chimney, Masonry. A field-constructed chimney of solid masonry units, bricks, stones, listed masonry chimney units, or reinforced Portland cement concrete, lined with approved suitable chimney flue liners. [NFPA 54:3.3.18.3]

207.0  – E –

Effective Ground-Fault Current Path. An intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground-fault detectors on high-impedance grounded systems. [NFPA 54:3.3.34]

209.0  – G –

Gas Convenience Outlet. A permanently mounted, hand-operated device providing a means for connecting and disconnecting an appliance or an appliance connector to the gas supply piping. The device includes an integral, manually operated gas valve with a nondisplaceable valve member so that disconnection can be accomplished only where the manually operated gas valve is in the closed position. [NFPA 54:3.3.48]

224.0  – V –

Vent Offset. An arrangement of two or more fittings and pipe installed for the purpose of locating a vertical section of vent pipe in a different but parallel plane with respect to an adjacent section of a vertical vent pipe. [NFPA 54:3.3.102]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Chapter 2 is being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 26
Item #: 011
UMC 2021  Section: 301.3

**SUBMITTER:** Randy Young  
Sacramento JATC

**RECOMMENDATION:**
Revise text

301.0 General.

301.3 Design of Equipment. The installing contractor Installers shall furnish satisfactory evidence that the appliance is constructed in accordance with the requirements of this code. The permanently attached label of an approved agency shall be permitted to be accepted as such evidence.

**SUBSTANTIATION:**
Placing the burden of proof on the installer does not make sense, the installing contractor is the responsible entity.

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

Amend proposal as follows:

301.0 General.

301.3 Design of Equipment. The installing installer or contractor shall furnish satisfactory evidence that the appliance is constructed in accordance with the requirements of this code. The permanently attached label of an approved agency shall be permitted to be accepted as such evidence.

**COMMITTEE STATEMENT:**
The term "installing contractor" is being revised as it is the "installer or contractor" who must comply with the requirements of the UMC.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**  AFFIRMATIVE: 26
Item #: 012

UMC 2021  Section: 301.4

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

301.0 General.

301.4 Electrical Connections. For equipment regulated by this code:

(1) Equipment requiring electrical connections of more than 50 volts shall have a positive means of disconnect adjacent to and in sight from the equipment served.

Exception: Other power disconnect means shall be acceptable where in accordance with NFPA 70.

(2) A 120 volt receptacle shall be located within 25 feet (7620 mm) of the equipment for service and maintenance purposes. The receptacle outlet shall be on the supply side of the disconnect switch. The receptacle need not be located on the same level as the equipment.

(3) Electrical wiring, controls, and connections to equipment and appliances regulated by this code shall be in accordance with NFPA 70.

SUBSTANTIATION:
NFPA 70 adequately covers the electrical requirements for equipment regulated by this code. The proposed change will properly reference NFPA 70 for the electrical requirements. NFPA 70 covers the requirements in 301.4(1) and(2) in greater detail and clarity than does the code. By removing specific electrical requirements from this code and leaving them in NFPA 70 guarantees that there will be no conflicts between the codes. 1. The phrase “positive means of disconnect” is vague and unenforceable and does not appear in NFPA 70 or other electrical codes. 2. The phrases “adjacent to” and “in sight from” have no definition in the UMC and are subjective. NFPA 70 defines “in sight from” as: In Sight From (Within Sight From, Within Sight). Where this Code specifies that one equipment shall be “in sight from,” “within sight from,” or “within sight of,” and so forth, another equipment, the specified equipment is to be visible and not more than 15 m (50 ft) distant from the other. 3. There is a conflict with item (2) and NFPA 70 Section 210.63. NFPA 70 requires the receptacle installed for servicing HVAC equipment to be located on the same level as the equipment. 4. Receptacles are rated at 125 volt not 120 volt in accordance with UL 489. Branch circuits are rated at 120 volts nominal.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion is being rejected as the text should remain and is needed for enforcement of the code regarding electrical connections.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 26
Proposals

Edit Proposal

Item #: 013

UMC 2021 Section: 302.1

SUBMITTER: Ronald George, CPD, President
Plumb-Tech Design & Consulting Services LLC

RECOMMENDATION:
Revise text

302.0 Materials- Standards and Alternates.

302.1 Minimum Standards.
Listed pipe, pipe fittings, appliances, appurtenances, equipment, materials, and devices used in a mechanical system shall be installed in accordance with the scope of the applicable standards for the product. Products 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 mechanical systems, or parts thereof, shall be submitted to the Authority Having Jurisdiction for approval.

SUBSTANTIATION:
It is important for a product to be installed in accordance with the scope for which the product standard was developed. There are many products that have specific applications spelled out in the "scope" of the standard and using the devices in an application that does not comply with the scope of the standard could create a danger or hazard to users. Example #1: Temperature control device standards identify the applications for use of the product in the "scope" which defines how the product should be used. If someone were to install an ASSE 1017 Temperature actuated mixing valve on the water supply to an emergency fixture system, it would be the wrong application and violate the scope of the standard along with exposing the users to serious scald dangers. The proper mixing valve for an emergency fixture application as noted in the scope of the standard ASSE 1071 devices are designed to by-pass cold water in the event of a failure or over-temperature situation. Example # 2: An ASSE 1017 temperature actuated mixing valve for building water distribution systems should not be used for a gang shower application because the 1017 standard allows (Up to plus or minus 7 Degrees from the set point) large temperature swings would be inappropriate for single temperature metering faucets or single temperature on/off type gang showers. The appropriate shower valve would need to be an ASSE 1069 device which is designed to control temperature to a very accurate range for tempered water applications. There are many other examples

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is unenforceable. Furthermore, not all standards contain installation requirements within their scope.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 26
Proposals
Edit Proposal
Item #: 014
UMC 2021 Section: 302.1

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

302.0 Materials – Standards and Alternates.

302.1 Minimum Standards. Listed pipe, pipe fittings, appliances, appurtenances, equipment, materials, and devices used in a mechanical system 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 mechanical systems, or parts thereof, shall be submitted to the Authority Having Jurisdiction for approval prior to product being installed.

SUBSTANTIATION:
Adding language that these products or items need to be approved prior to using them on site.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

302.0 Materials – Standards and Alternates.

302.1 Minimum Standards. Listed pipe, pipe fittings, appliances, appurtenances, equipment, materials, and devices used in a mechanical system 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 mechanical systems, or parts thereof, shall be submitted to the Authority Having Jurisdiction for approval prior to product being installed.

COMMITTEE STATEMENT:
The term “product” creates confusion. Removing the term “product” clarifies the intent of the proposal.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 26
Proposals
Edit Proposal
Item #: 015
UMC 2021  Section: 303.1, Table 1701.1

SUBMITTER: David C. Bixby
Air Conditioning Contractors of America

RECOMMENDATION:
Revise text

303.0 Installation.
303.1 Listed Appliances. The installation of equipment and appliances regulated by this code shall be in accordance with the conditions of the listing, the manufacturer’s installation instructions and this code. The manufacturer’s installation and operating instructions shall be attached to the appliance. Minimum criteria for the proper installation of HVAC systems shall comply with ACCA 5 QI. Clearances of listed equipment and appliances from combustible materials shall be as specified in the listing or on the rating plate.

TABLE 1701.1
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>ANSI/ACCA 5 QI-2015</td>
<td>HVAC Quality Installation Specification</td>
<td>Equipment</td>
<td>303.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ACCA 5 QI meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
ACCA 5 QI details nationally-recognized minimum criteria for the proper installation of HVAC systems in new and existing residential and commercial buildings. This standard provides a universally accepted definition for quality installation across a broad spectrum of the HVAC industry (e.g., manufacturers, distributors, contractors, user groups, customers, utilities, efficiency advocates, trade associations, professional societies, and governmental agencies). In this Standard, the QI elements focus on the application and how well the system is selected and actually installed. ACCA 5 QI is also a consensus-based ANSI standard. The addition of ACCA 5 QI is needed to support its proposed reference as a new requirement under 303.1. ACCA 5 QI is a consensus-based ANSI standard that meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Projects.

COMMITTEE ACTION: REJECT
COMMITTEE STATEMENT:
The proposed text is not needed as the manufacturer’s installation instructions already provide installation procedures and the manufacturer’s installation instructions take precedence.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS:  AFFIRMATIVE: 24    NEGATIVE: 1    NOT RETURNED: 1 Howard
EXPLANATION OF NEGATIVE:
WHITE: ACCA 5 QI is an industry supported standard necessary for quality installations.
Item #: 016

UMC 2021  Section: 303.3

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

303.0 Installation.

303.3 Unlisted Appliances. Except as otherwise permitted in this code, unlisted equipment and appliances shall be approved by the Authority Having Jurisdiction prior to being installed. Unlisted equipment and appliances shall be installed in accordance with the manufacturer’s installation instructions and with clearances from combustible materials in accordance with Section 303.10 or Section 303.10.1.

SUBSTANTIATION:
Adding "prior to being installed" as any items substituted should always be approved prior to installation.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 26
Item #: 017

UMC 2021  Section: 303.8.4, Table 1701.1

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

303.0 Installation.

303.8 Appliances on Roofs. (remaining text unchanged)

303.8.4 Edge of Roof Clearance. Appliances shall be installed on a well-drained surface of the roof. At least 6 feet (1829 mm) of clearance shall be available between any part of the appliance and the edge of a roof or similar hazard.

303.8.4.1 Guards. Where the clearance between the appliance and the edge of roof is not met as required in Section 303.8.4, rigidly fixed rails, guards, parapets, or other building structures at least 42 inches (1067 mm) in height shall be provided on the exposed side. [NFPA 54:9.4.2.2] Guards shall not be required where personnel fall protection in accordance with ASSE Z359.1 is installed.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSE Z359.1-2016</td>
<td>The Fall Protection Code</td>
<td>Miscellaneous</td>
<td>303.8.4.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ASSE Z359.1 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
Section 303.8.4 is being revised to separate the guards requirement in a separate location for ease of use of the document. Furthermore, guards are not necessary when there is a personnel fall protection provided in accordance with ASSE Z359 is installed. This is similar to the current OSHA requirements.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language will create confusion and conflict with the NFPA 54 Extract.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NEGATIVE: 1

EXPLANATION OF NEGATIVE:

SMITH: The monograph needs to be re-written to conform. The provisions for fall protection are needed in the code.
Item #: 018
UMC 2021  Section: 303.8.5

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Delete text without substitution

303.0 Installation.

303.8 Appliances on Roofs. (remaining text unchanged)

303.8.5 Electrical Power. All appliances requiring an external source of electrical power for its operation shall be provided with the following:
(1) A readily accessible electrical disconnecting means within sight of the appliance that completely de-energizes the appliance.
(2) A 120-volt 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]

(renumber remaining sections)

SUBSTANTIATION:
UMC Section 301.4 already covers this requirement. There is no need to reiterate these requirements for equipment located on roofs. NFPA 70 adequately covers the electrical requirements for equipment regulated by this code. By removing specific electrical requirements from this code and leaving them in NFPA 70 it guarantees that there will be no conflicts between the codes. Proposals are being submitted to NFPA to address this issue in NFPA 54 National Fuel Gas Code. 1. The phrases “adjacent to” and “in sight from” have no definition in the UMC and are subjective. NFPA 70 defines “in sight from” as: In Sight From (Within Sight From, Within Sight). Where this Code specifies that one equipment shall be “in sight from,” “within sight from,” or “within sight of,” and so forth, another equipment, the specified equipment is to be visible and not more than 15 m (50 ft) distant from the other. 2. There is also a conflict with item (2). Receptacles are rated at 125 volt not 120 volt in accordance with UL 489. Branch circuits are rated at 120 volts nominal.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text deletion should remain in the code as the language is needed for enforcement of the code. Furthermore, the substantiation lacks technical justification to support the proposed change.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 019
UMC 2021  Section: 303.10.1, 303.10.1.1

SUBMITTER: Mohamed Dano
Control Air Conditioning Corporation

RECOMMENDATION:
Revise text

303.0 Installation.

303.10 Clearances. (remaining text unchanged)

303.10.1 Clearance Reduction. Reduce clearances to combustible construction for listed equipment and appliances shall comply with the listing and Table 303.10.1, except for specific applications and provision as stated in Section 303.10.1.1 through Section 303.10.1.3. Where permitted by the manufacturer, and not provided in this code, reduce clearances to combustible construction for unlisted equipment and appliances shall comply with Table 303.10.1.

303.10.1.1 Type I Hood Exhaust System, Commercial Kitchens. Reduce clearances for Type I exhaust systems used in commercial kitchens shall be in accordance with Section 507.4.2 through Section 507.4.2.3. Clearances from the duct or the exhaust fan to the interior surface of enclosures of combustible construction shall be in accordance with Section 510.7.3 and clearances shall not be reduced.

SUBSTANTIATION:
Section 303.10.1 and Section 303.10.1.1 is being revised for clarity. For example, Section 303.10.1 should be revised to include language which sends the end user for specific reduce clearances requirements. The current language seems to indicate that all reduce clearances must comply with Table 303.10.1 which is not the case. Section 303.10.1.1 is being revised to clarify that the section is specific to commercial kitchens. Thought the term “Type 1” it is common language for those of us who deal with these types of systems in our daily lives, it is not is not common language for those contractors or installers who may come across with these systems.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is not necessary and does not enhance and strengthen the enforceability of the code.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 26
Proposals

Item #: 020
UMC 2021  Section: 303.10.1.3

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

303.0 Installation.

303.10 Clearances. (remaining text unchanged)
303.10.1 Clearance Reduction. (remaining text unchanged)

303.10.1.3 Solid-Fuel Burning Appliances. For solid-fuel burning appliances, the clearance, after reduction, shall not be less than 12 inches (305 mm) to combustible walls and not less than 18 inches (457 mm) to combustible ceilings. The clearance, after reduction, shall be permitted to be less than 12 inches (305 mm) to combustible walls and less than 18 inches (457 mm) to combustible ceilings where the solid-fuel burning appliances is listed for lesser clearance. Solid-fuel burning appliances listed for lesser clearances shall be permitted to be installed in accordance with the manufacturer’s instructions and their listing.

SUBSTANTIATION:
This made no sense as written, with "after reduction" in the first sentence made this seem contradictory. Simple clean up.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 26
Item #: 021
UMC 2021  Section: 303.13

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

305.0 Location.

303.13 305.2 Pit Location. Where excavation is necessary to install an appliance, it shall extend to a depth shall extend not less than of 6 inches (152 mm) below and 12 inches (305 mm) on all sides of the appliance, except on the service side, which shall have 30 inches (762 mm). Where the depth of the excavation for either the appliance or passageway exceeds 12 inches (305 mm), walls shall be lined with concrete or masonry 4 inches (102 mm) above the adjoining ground level.

(renumber remaining sections)

SUBSTANTIATION:
Section 305.2 is being revised to clarify that the distance beneath the appliance when installed in pit location. Furthermore, the section is being relocated from the installation section to the location section as it pertains to the location.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 022

UMC 2021  Section: 304.4.4

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Delete text without substitution

304.0 Accessibility for Service.

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

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

SUBSTANTIATION:
The requirements for lighting and power for appliances installed in Attics and underfloor spaces are adequately covered in NFPA 70 Sections 210.63, 210.70(A)(3) and 210.70(C). There are conflicts with some of the terms used in this section and the corresponding requirements found in NFPA 70. (1) The term “Lighting Fixture” has been replaced in the 2002 edition of NFPA 70 with the term “Luminaire”. The term luminaire is used internationally for lighting products. The NEC permits the required illumination for an appliance to be provided by either a lampholder or a luminaire. (2) Receptacles are rated at 125 volt not 120 volt in accordance with UL 489. Branch circuits are rated at 120 volts nominal. Proposals are being submitted to NFPA to address this issue in NFPA 54 National Fuel Gas Code.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text deletion should remain in the code as the language is needed for enforcement of the code in regards to lighting and power for appliances.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Proposals

Item #: 023

UMC 2021  Section: 310.2

SUBMITTER:  Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

310.0 Condensate Wastes and Control.

310.2 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 310.1. 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 3/4 of an inch (20 mm) nominal pipe size, discharging at a point that is readily observed.

SUBSTANTIATION:
Where equipment or appliances are installed in any area and condensate has a potential of causing any damage, proper precautions should be taken to prevent such damage. Ceiling tiles are like sponges, they will accept and retain moisture which could lead to mold and mildew growth. Damage to items located below the ceiling such as files, computers, desks or whatever else the building owner decides to place under an area unknown to him/her if the ceiling is going to hiding a leaky hazard.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25   NOT RETURNED: 1   HOWARD
Item #: 023.01
UMC 2021  Section: Table 313.3

SUBMITTER: UMC Technical Committee Proposal

RECOMMENDATION:
Add new text

TABLE 313.3
HANGERS AND SUPPORTS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPVC-AL-CPVC</td>
<td>Solvent Cemented</td>
<td>½ inch, 5 feet; ¾ inch, 5.5 feet; 1 inch, 6 feet</td>
<td>Base and each floor; provide mid-story guide</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:
CPVC-AL-CPVC was added to Chapter 12 last cycle and hanger and support spacings were not added at that time. The proposed spacing was calculated at 180°F with a max ¼ inch sag and rounded to the closest ½ foot. Calculations are attached.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
Amend proposal as follows:

TABLE 313.3
HANGERS AND SUPPORTS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPVC-AL-CPVC</td>
<td>Solvent Cemented</td>
<td>½ inch, 5 feet; ¾ inch, 5.5 feet; 1 inch, 6 feet</td>
<td>Base and each floor; provide mid-story guide</td>
</tr>
</tbody>
</table>

( порций of table not shown remain unchanged)

COMMITTEE STATEMENT:
The proposed modification clarifies the proposed intent by changing 5.5 feet to 65 inches.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 024
UMC 2021  Section: 316.8

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Delete text without substitution

316.0 Protection of Piping, Tubing, Materials, and Structures.

316.8 Firewalls. A pipe sleeve through a firewall shall have the space around the pipe or tubing completely sealed with an approved fire-resistive material in accordance with other codes.

(renumber remaining sections)

SUBSTANTIATION:
This requirement is more appropriately covered in the building codes. Section 316.5 properly directs code users to the building code for the requirements for penetrating fire-resistance rated construction with piping, tubing and duct systems. Penetrations of fire rated construction is not germane to just “fire walls”. Building codes address a multitude of fire resistance rated assemblies including “fire barriers”, “fire partitions”, “fire walls” and horizontal assemblies to name a few. Horizontal and vertical fire resistance rated assemblies have very specific requirements for penetrations that include pipe sleeve materials, forming materials, fill materials etc. These requirements are suitably covered in the approved through penetration firestop systems specified in the building codes.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text deletion would remove language that is needed for enforcement purposes in regards to pipe sleeves through a firewall.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NEGATIVE: 1

EXPLANATION OF NEGATIVE:
HEINE: This would remove language needed for enforcement of the code.
Item #: 025

UMC 2021  Section: Chapter 3: 303.8.2

SUBMITTER: IAPMO Staff - Update Extracts
   NFPA 54 Extract Update

RECOMMENDATION:
Revise text

303.0 Installation.

303.8.2 Fasteners. **Access All access** locks, screws, and bolts shall be of corrosion-resistant material. [NFPA 54:9.4.1.3]

Notes:
1 A – Equals the clearance with no protection specified in Table 802.7.3.3 and Table 904.2.2 and in the sections applying to various types of **appliances equipment**.
2 B – Equals the reduced clearance permitted in accordance with Table 303.10.1.
3 The protection applied to the construction using combustible material shall extend far enough in each direction to make C equal to A.

**FIGURE 303.10.1(1)**

EXTENT OF PROTECTION NECESSARY TO REDUCE CLEARANCES FROM GAS APPLIANCES OR VENT CONNECTORS
[NFPA 54: FIGURE 10.3.2.3(a)]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Section 303.8.2 and Figure 303.10.1(1) are being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 026
UMC 2021 Section: 401.1, 405.0 - 405.5, 217.0, Table 1701.1, Table 1701.2

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

401.0 General.
401.1 Applicability. This chapter contains requirements for ventilation air supply, exhaust, and makeup air requirements for occupiable spaces within a building. Spaces within buildings, except those within dwelling unit in residential occupancies where occupants are nontransient, shall comply with Section 402.0 through Section 404.0. 402.1.2 Dwelling. Requirements for ventilation air rate for single family dwellings units in residential occupancies, where the occupants are nontransient, shall be in accordance with this chapter or ASHRAE 62.2 Section 405.0.

405.0 Indoor Air Quality for Residential Occupancies.

405.1 General. Rooms or occupied spaces within residential occupancies, where the occupants are nontransient, shall be designed to have mechanical ventilation and exhaust air in accordance with Section 405.2 through Section 405.5.

405.1.1 Natural Ventilation. Where approved by the Authority Having Jurisdiction, natural ventilation shall be permitted for Climate Zone 1, Climate Zone 2, or for thermally conditioned buildings for less than 876 hours per year.

405.2 Ventilation Air Rate. The required mechanical ventilation outdoor air rate \( Q_{\text{tot}} \) shall be as calculated in accordance with Equation 405.2. Exceptions: For existing buildings and where permitted by the Authority Having Jurisdiction, the total mechanical ventilation \( Q_{\text{tot}} \) is not required where \( Q_{\text{tot}} \) is calculated to be not more than 15 ft\(^3\)/min (0.007 m\(^3\)/s).

\[
Q_{\text{tot}} = 0.03 A_{\text{floor}} + 7.5 (N_{\text{br}} + 1) \quad \text{Equation 405.2}
\]

Where:
- \( Q_{\text{tot}} = \) Total required ventilation outdoor air rate, cfm
- \( A_{\text{floor}} = \) Floor area, ft\(^2\)
- \( N_{\text{br}} = \) Number of bedrooms more than 1

For SI Units: 1 cubic foot per minute = 0.00047 m\(^3\)/s

405.2.1 Reduced Ventilation Air Rate. Where permitted by the Authority Having Jurisdiction, the mechanical ventilation air rate required in Section 405.2 shall be permitted to be reduced where an infiltration rate is determined in accordance with ASTM E779.

405.3 Bathroom Exhaust. A mechanical exhaust directly to the outdoors shall be provided in each room containing a bathtub, shower, or tub/shower combination. The fan shall run intermittently (on demand) or continuously. A readily accessible manual control designed to be operated as needed or an automatic control shall be provided for intermittent operations.

405.3.1 Exhaust Rate. The exhaust rate shall be not less than 50 ft\(^3\)/min (0.02 m\(^3\)/s) for intermittent operation and 20 ft\(^3\)/min (0.009 m\(^3\)/s) for continuous operation.

405.4 Kitchen Exhaust. A mechanical exhaust directly to the outdoors shall be provided in each kitchen. The fan shall run intermittently (on demand) or continuously. A readily accessible manual control designed to be operated as needed or an automatic control shall be provided for intermittent operations.

405.4.1 Exhaust Rate. For intermittently-controlled operations, the exhaust rate shall be not less than 100 ft\(^3\)/min (0.047 m\(^3\)/s) for range hoods or 200 ft\(^3\)/min (0.141 m\(^3\)/s) for mechanical exhaust fans including downdraft appliances. For continuous-operated ventilation, the exhaust rate shall be not less than 5 air changes per hour based on kitchen volume for enclosed kitchens.

405.5 Ventilation Openings. Occupiable spaces shall be provided with a readily accessible ventilation opening openable to the outdoors. The opening shall be not less than 5 square feet (0.464 m\(^2\)) or 4 percent of the occupied floor area. The openable area shall be based on free, unobstructed area through the opening.
### 217.0  – O –

**Occupancy, Nontransient.** Occupancy of a dwelling unit or sleeping unit for more than 30 days. [ASHRAE 62.1-3]

#### TABLE 1701.1
**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 E779-2010</td>
<td>Standard Test Method for Determining Air Leakage Rate by Fan Pressurization</td>
<td>Air Ducts</td>
<td>405.2.1</td>
</tr>
<tr>
<td>ASHRAE 62.2-2016</td>
<td>Ventilation and Acceptable Indoor Air Quality</td>
<td>Ventilation</td>
<td>402.1.2</td>
</tr>
</tbody>
</table>

(Note: ASTM E779 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.)

### TABLE 1701.2
**STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES**

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE 62.2-2016</td>
<td>Ventilation and Acceptable Indoor Air Quality</td>
<td>Ventilation</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**SUBSTANTIATION:**

The current ventilation requirements are not consistent with current industry standards. For example, the ventilation air rates in Chapter 4 are only applicable to occupancies which are transient. Previously, it applied to occupancies for 3 stories or higher above ground; however, this was changed about 2 years ago. Therefore, provisions for transient and nontransient are required for consistency with current industry practices and standards. The current text in Chapter 4 is providing a disservice to the industry as it only provides partial requirements which are not consistent with industry standards. The proposed language will provide the necessary minimum requirements for both transient and nontransient occupancies which are consistent with the current industry standards. This proposal only addresses the proper ventilation requirements required for both transient and nontransient (dwelling units within residential occupancies) that are necessary in the field. It is easy to use. One of the issues experienced in the field is that ASHRAE 62.2 addresses requirements which are unenforceable. Not to mention, the standard not being user friendly. It is proposed that only the enforceable provisions with the necessary edits be added to Chapter 4 for ease of use. If the exact requirements to ASHRAE 62.2 are necessary, then the jurisdiction can adopt Appendix E where the exact wording from ASHRAE 62.2 is addressed. However, as mentioned, the current ASHRAE 62.2 is difficult to apply and most of it is written in such a way that is unenforceable.

**COMMITTEE ACTION:** REJECT

**COMMITTEE STATEMENT:**

The Technical Committee agrees with the concept of this proposal, however, further research is needed to address the proposed language and equation in Section 405.2.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25  NEGATIVE: 1

**EXPLANATION OF NEGATIVE:**

**HOWARD:** The inclusion of the ASTM document will conflict with existing code.
402.2 Ventilation Air.

402.2 Natural Ventilation. Natural ventilation systems shall be designed in accordance with this section and shall include mechanical ventilation systems designed in accordance with Section 403.0, Section 404.0, or both.

Exceptions:
(1) An engineered natural ventilation system where approved by the Authority Having Jurisdiction need not comply with Section 402.2.
(2) A

The mechanical ventilation system is

systems shall

not be

required where:
(a) natural ventilation openings that comply with the requirements of Section 402.2 and are permanently open or have controls that prevent the openings from being closed during periods of expected occupancy or
(b) the zone is not served by heating or cooling equipment. [ASHRAE 62.1:6.4]

402.2.1 Floor Area to Be Ventilated. Spaces, or portions of spaces, to be naturally ventilated shall be located within a distance based on the ceiling height, as determined in accordance with Section 402.2.1.1, Section 402.2.1.2, or Section 402.2.1.3, from operable wall openings in accordance with the requirements of Section 402.2.2. For spaces with ceilings which are not parallel to the floor, the ceiling height shall be determined in accordance with Section 402.2.1.4. [ASHRAE 62.1:6.4.1]

402.2.1.3 Corner Openings. For spaces with operable openings on two adjacent sides of a space, such as two sides of a corner, the distance from the operable openings shall be not more than 5H along a line drawn between the two openings that are farthest apart. Floor area outside that line shall comply with Section 402.2.1.1. [ASHRAE 62.1:6.4.1.3]

402.2.2 Location and Size of Openings. Spaces, or portions of spaces, to be naturally ventilated shall be permanently open to operable wall openings directly to the outdoors, the openable area of which is a minimum of shall be not less than 4 percent of the net occupiable floor area. Where openings are covered with louvers or otherwise obstructed, openable area shall be based on the net free unobstructed area through the opening. Where interior rooms, or portions of rooms, without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and shall have a free area of not less than 8 percent of the area of the interior room nor or less than 25 square feet (2.3 m²). [ASHRAE 62.1:6.4.2]

403.0 Ventilation Rates.

403.2.1 Breathing Zone Outdoor Airflow. The outdoor airflow required in the breathing zone \( V_{bz} \) of the occupiable space or spaces in a ventilation zone, i.e., the breathing zone outdoor airflow \( V_{bz} \), shall be not less than the value determined in accordance with Equation 403.2.1.

\[
V_{bz} = R_p \cdot P_z + R_d \cdot A_z
\]  
(Equation 403.2.1)

Where:
\( A_z \) = zone floor area; the net occupiable floor area of the ventilation zone, square feet (m²).
\( P_z \) = zone population; The number of people in the ventilation zone during typical usage.
\( R_p \) = outdoor airflow rate required per person as determined from Table 402.1.
403.2.3 Zone Outdoor Airflow. The zone outdoor airflow ($V_{oz}$), i.e., the outdoor airflow rate that shall be provided to the ventilation zone by the supply air distribution system, shall be determined in accordance with Equation 403.2.3. [ASHRAE 62.1:6.2.2.3]

$$V_{oz} = V_{bz}/E_z$$

(Equation 403.2.3)

403.5.1 Primary Outdoor Air Fraction. The primary outdoor air fraction ($Z_{pz}$) shall be determined for ventilation zones in accordance with Equation 403.5.1. [ASHRAE 62.1:6.2.5.1]

$$Z_{pz} = V_{oz}/V_{pz}$$

(Equation 403.5.1)

Where:
- $V_{pz}$ is the zone primary airflow, i.e., the primary airflow rate to the ventilation zone from the air handler, including outdoor air and recirculated air.

For VAV-system design purposes, $V_{pz}$ is the lowest zone primary airflow value expected at the design condition analyzed. It shall be permitted to determine these parameters for only selected zones as outlined in Section 404.0. [ASHRAE 62.1:6.2.5.1]

403.6.1 Short-Term Conditions. Where it is known that peak occupancy will be of short duration, or the ventilation will be varied or interrupted for a short period of time, or both, the design shall be permitted to be based on the average conditions over a time period ($T$) determined in accordance with Equation 403.6.1.

$$T = 3v/V_{bz}$$

(Equation 403.6.1)

Where:
- $T$ = averaging time period, minutes.
- $v$ = the volume of the ventilation zone for which averaging is being applied, cubic foot (ft$^3$).
- $V_{bz}$ = the breathing zone outdoor airflow calculated in accordance with Equation 403.2.1 and design value of the zone population ($P_z$), cubic foot per minute (cfm) (m$^3$/min).

Acceptable design adjustments based on this optional provision shall be in accordance with including the following:
1. Zones with fluctuating occupancy: The zone population ($P_z$) shall be permitted to be averaged over time ($T$).
2. Zones with intermittent interruption of supply air: The average outdoor airflow supplied to the breathing zone over time ($T$) shall be not less than the breathing zone outdoor airflow ($V_{bz}$) calculated using Equation 403.2.1.
3. Systems with intermittent closure of the outdoor air intake: The average outdoor air intake over time ($T$) shall be not less than the minimum outdoor air intake ($V_{oi}$) calculated using Equation 403.3, Equation 403.4, or Equation 403.5.4. [ASHRAE 62.1:6.2.6.2]

403.8 Dynamic Reset. The system shall be permitted to be designed to reset the outdoor air intake flow ($V_{oi}$), the space or ventilation zone airflow ($V_{oz}$) as operating conditions change, or both. [ASHRAE 62.1:6.2.7]

403.9 Air Classification and Recirculation. Air shall be classified, and the its recirculation or transfer shall be limited in accordance with Section 403.9.1 through Section 403.9.4. [ASHRAE 62.1:5.16] Recirculated air shall not be taken from prohibited locations in accordance with Section 311.3.

403.9.4 Class 4 Air. Class 4 air shall not be recirculated or transferred to any other space or be recirculated within the space of origin. [ASHRAE 62.1:5.16.3.4]

404.0 Multiple-Zone Systems.

404.3 Zone Ventilation Efficiency. The zone ventilation efficiency ($E_{vz}$) shall be the efficiency with which a system distributes outdoor air from the intake to an individual breathing zone, and shall be determined in accordance with Section 404.3.1 or Section 404.3.2. [ASHRAE 62.1:A1.2]
<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY</th>
<th>PEOPLE OUTDOOR Air Rate Rp (Cfm/Person)</th>
<th>AREA OUTDOOR Air Rate RA(Cfm/ft²)</th>
<th>DEFAULT OCCUPANT DENSITY (people/1000 ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EDUCATIONAL FACILITIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture classroom</td>
<td>7.5</td>
<td>0.06</td>
<td>65</td>
<td>1</td>
</tr>
<tr>
<td>Lecture hall (fixed seats)</td>
<td>7.5</td>
<td>0.06</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Multi-use assembly</td>
<td>7.5</td>
<td>0.06</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Music/theater/dance</td>
<td>10</td>
<td>0.06</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td><strong>GENERAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break rooms</td>
<td>5</td>
<td>0.06</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Coffee stations</td>
<td>5</td>
<td>0.06</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Conference/meeting</td>
<td>5</td>
<td>0.06</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Corridors</td>
<td>–</td>
<td>0.06</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td><strong>HOTELS, MOTELS, RESORTS, DORMITORIES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barracks sleeping areas</td>
<td>5</td>
<td>0.06</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Bedroom/living room</td>
<td>5</td>
<td>0.06</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Lobbies/pre-function</td>
<td>7.5</td>
<td>0.06</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Multipurpose assembly</td>
<td>5</td>
<td>0.06</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td><strong>OFFICE BUILDINGS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main entry lobbies</td>
<td>5</td>
<td>0.06</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Office space</td>
<td>5</td>
<td>0.06</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Reception areas</td>
<td>5</td>
<td>0.06</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Telephone/data entry</td>
<td>5</td>
<td>0.06</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td><strong>MISCELLANEOUS SPACES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank or bank lobbies</td>
<td>7.5</td>
<td>0.06</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Bank vaults/safe deposit</td>
<td>5</td>
<td>0.06</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Computer (not printing)</td>
<td>5</td>
<td>0.06</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Transportation waiting</td>
<td>7.5</td>
<td>0.06</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td><strong>PUBLIC ASSEMBLY SPACES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auditorium seating area</td>
<td>5</td>
<td>0.06</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Courtrooms</td>
<td>5</td>
<td>0.06</td>
<td>70</td>
<td>1</td>
</tr>
<tr>
<td>Legislative chambers</td>
<td>5</td>
<td>0.06</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Lobbies</td>
<td>5</td>
<td>0.06</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Museums/galleries</td>
<td>7.5</td>
<td>0.06</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>Places of religious worship</td>
<td>5</td>
<td>0.06</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td><strong>RESIDENTIAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common corridors</td>
<td>–</td>
<td>0.06</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Dwelling unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. 2. ASHRAE 62.1: TABLE 6.2.2.1
### Table 402.1

<table>
<thead>
<tr>
<th>ITEM</th>
<th>VOLUME (cu ft/min)</th>
<th>AIR TEMPERATURE (°F)</th>
<th>OCCUPANT CATEGORY</th>
<th>OCCUPANCY LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barber Shop</td>
<td>7.5</td>
<td>0.06</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Mall Common Areas</td>
<td>7.5</td>
<td>0.06</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>Supermarket</td>
<td>7.5</td>
<td>0.06</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

**Notes:**
1. This table applies to no-smoking areas. Rates for smoking-permitted spaces shall be determined using other methods.
2. Volumetric airflow rates are based on an dry air density of 0.075 pounds of dry air per cubic foot (lbda/ft³) (1.201 kgda/m³), which corresponds to dry air at a barometric pressure of 1 atm (101 kPa) and an air temperature of 70°F (21°C). Rates shall be permitted to be adjusted for actual density, but such adjustment is not required for compliance with this chapter.
3. - (4) (text unchanged)

**ITEM-SPECIFIC NOTES FOR TABLE 402.1**

a. For high school and college libraries, use the values shown for “Public Assembly Spaces – Libraries” shall be used.
b. Rate is capable of may not be sufficient where stored materials include those having potentially harmful emissions.
c. Rate does not allow for humidity control. Additional ventilation or dehumidification shall be permitted to remove moisture.
d. Rate does not include special exhaust for stage effects, e.g., dry ice vapors, and smoke.
e. Where combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation, source control, or both shall be provided.
f. Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.
g. Air from one residential dwelling shall not be recirculated or transferred to other spaces outside of that dwelling.
h. Ventilation air for this occupancy category shall be permitted to be reduced to zero where the space is in occupied-standby mode.

### Table 403.7

**MINIMUM EXHAUST RATES [ASHRAE 62.1: TABLE 6.5]**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>VOLUME (cu ft/min)</th>
<th>AIR TEMPERATURE (°F)</th>
<th>OCCUPANCY LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disco/dance floors</td>
<td>20</td>
<td>0.06</td>
<td>100</td>
</tr>
<tr>
<td>Spectator areas</td>
<td>7.5</td>
<td>0.06</td>
<td>150</td>
</tr>
<tr>
<td>Stages, studios</td>
<td>10</td>
<td>0.06</td>
<td>70</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.0283 m³/min, 1 square foot = 0.0929 m²

**Notes:**
1. (text unchanged)
2. Exhaust rate is shall not be required for where two or more sides comprise walls that are at least 50 percent open parking garages as defined in accordance with to the building code outside.
3. Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur, e.g., toilets in theatres, schools, and sports facilities. Otherwise the lower rate shall be permitted to be used otherwise.
4. (text unchanged)
SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Chapter 4 has been revised to correlate with latest edition of ASHRAE 62.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
403.0 Ventilation Rates.

403.7 Exhaust Ventilation. (remaining text unchanged)

403.7.2 Enclosed Parking Garages. Mechanical ventilation systems for enclosed parking garages shall operate continuously. Exceptions:

(1) Mechanical ventilation systems shall be permitted to operate intermittently where the system is designed to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices. Approved automatic carbon monoxide sensing devices, and nitrogen dioxide detectors shall be permitted to be employed to modulate the ventilation system to not exceed a maximum average concentration of carbon monoxide of 50 parts per million of carbon monoxide, or 1 part per million nitrogen dioxide during an eight-hour period; with a concentration of not more than 200 parts per million for carbon monoxide, or 5 parts per million nitrogen dioxide, for a period not exceeding one hour 15 minutes. Automatic carbon monoxide sensing devices installed in modulated parking garage ventilation systems shall be approved in accordance with Section 301.2.

SUBSTANTIATION:
Most newer diesel vehicle exhaust cannot be detected by carbon monoxide detectors. Nitrogen dioxide detectors have been developed which will detect diesel emissions which will solve the concern about diesel vehicle emissions in enclosed parking garages.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 029

UMC 2021  Section: 502.2.1

SUBMITTER: Scott Wayland
ASHRAE

RECOMMENDATION:
Revise text

502.0 Termination.

502.2 Termination of Exhaust Ducts. (remaining text unchanged)

502.2.1 Environmental Air Ducts. Environmental air duct exhaust shall terminate not less than 3 feet (914 mm) from a property line, 10 feet (3048 mm) from a forced air inlet, and 3 feet (914 mm) from openings into the building. Environmental exhaust ducts shall not discharge onto a public walkway at an elevation less than 10 feet (3048 mm) above adjoining grade.

SUBSTANTIATION:
The code section is too prohibitive towards conventional design practice where the only place a tenant can discharge economizer air is out the front façade of a suite in a mixed use and/or multistory building. Additionally, the statement is too ambiguous for a local AHJ to enforce. the elements in the statement are not defined anywhere in the UMC or the architectural code, nor do you cross reference.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
No technical substantiation was provided to merit such change.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 21  NEGATIVE: 4  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
KOERBER: The proposal attempts to address the issue by allowing exhaust at a height at least equal to the 10 foot distance to inlets.
P. TRAFTON: At 10' above grade, environmental exhaust does not create any conditions that would affect those in a public walkway.
HEINE: No substation was provided.
SMITH: The proposed change provides the best effort at a usable height.
Item #: 030

UMC 2021  Section: 502.2.1

SUBMITTER: Jeremy Martinez
Golden Gate Chapter ASHRAE
Rep: ASHRAE

RECOMMENDATION: 
Add new text

502.0 Termination.

502.2 Termination of Exhaust Ducts. (remaining text unchanged)
502.2.1 Environmental Air Ducts. Environmental air duct exhaust shall terminate not less than 3 feet (914 mm) from a property line, 10 feet (3048 mm) from a forced air inlet, and 3 feet (914 mm) from openings into the building. Environmental exhaust ducts shall not discharge onto a public walkway at an elevation less than 10 feet (3048 mm) above adjoining grade.

SUBSTANTIATION:
The code section is too prohibitive towards conventional design practice where the only place a tenant can discharge economizer air is out the front façade of a suite in a mixed use multistory building. Additionally, the statement is too ambiguous for a local AHJ to enforce.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
There is no technical substantiation to merit such change.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 22  NEGATIVE: 3  ABSTAIN: 1

EXPLANATION OF NEGATIVE:
SMITH: The proposed change provides the best effort at a usable height.

A. TRAFTON: Environmental exhaust discharging above a public walkway is a common practice and does not provide a negative environment.

P. TRAFTON: At 10’ above grade, environmental exhaust does not create any conditions that would affect those in a public walkway.

EXPLANATION OF ABSTAIN:
KOERBER: Prefer the proposed language in Item # 029; however more research is needed on my behalf; Therefore I am abstaining.
Item #: 031
UMC 2021  Section: 502.2.1, 502.2.2

SUBMITTER: Roham Naderi
Gouvis Engineering Consulting Group, Inc.

RECOMMENDATION:
Revise text

502.0 Termination.

502.2 Termination of Exhaust Ducts. (remaining text unchanged)

502.2.1 Environmental Air Ducts. Environmental air duct exhaust shall terminate not less than 3 feet (914 mm) from a property line, 10 feet (3048 mm) from a forced air inlet, and 3 feet (914 mm) from openings into a conditioned space of the building. Environmental exhaust ducts shall not discharge onto a public walkway.

502.2.2 Product Conveying Ducts. Ducts conveying explosive or flammable vapors, fumes, or dusts shall terminate not less than 30 feet (9144 mm) from a property line, 10 feet (3048 mm) from openings into a conditioned space of the building, 6 feet (1829 mm) from exterior walls or roofs, 30 feet (9144 mm) from combustible walls or openings into the building that are in the direction of the exhaust discharge, and 10 feet (3048 mm) above adjoining grade.

Other product-conveying outlets shall terminate not less than 10 feet (3048 mm) from a property line, 3 feet (914 mm) from exterior walls or roofs, 10 feet (3048 mm) from openings into the building, and 10 feet (3048 mm) above adjoining grade.

SUBSTANTIATION:
Section 502.2.1 and Section 502.2.2 is being revised to provide clarity in regards to the openings into the building. This section is intended for openings into a conditioned or occupiable space of the building. The definition for occupiable space excludes spaces such as storage rooms and equipment rooms that are only occupied for short periods of time. The exhaust terminations that penetrate through the exterior wall will only need to be located 3 feet from openings that are providing natural ventilation or is a conditioned space to the dwelling unit; it will not apply to garages.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
There are health and safety concerns in regards to exhaust from terminations near building openings being introduced into an unconditioned space.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 032
UMC 2021 Section: 505.6.1

SUBMITTER: Reinhard Hanselka
Menlo Park Fire Protection District

RECOMMENDATION:
Revise text

505.0 Product-Conveying Systems.

505.6 Fire Dampers. (remaining text unchanged)

505.6.1 Prohibited. Fire Dampers shall not be installed if the material being exhausted is Toxic, Highly Toxic, Unstable Reactive, Corrosive, Flammable, or a virulent Biologics and if a risk evaluation indicates that the hazard imposed is greater than the fire hazard.

SUBSTANTIATION:
This section was rewritten based on the Building and Fire Code hazard risk classes and the recognition that a closed damper will cause a potential great risk to the occupants within the room served by that specific exhaust system.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is vague and ambiguous. Furthermore, the proposed language does not improve the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 23 NEGATIVE: 3

EXPLANATION OF NEGATIVE:
HEINE: There is no improvement to the code and is very vague.
MACNEVIN: Proposed language included additional types of hazardous material descriptions that were substantiated; new language improves the section.
A. TRAFTON: New language improves the section.
Item #: 033

UCM 2021  Section: 506.1, 506.2, Table 1701.1, Table 1701.2

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

506.0 Product-Conveying Ducts.
506.1 Materials. Materials used in product-conveying duct systems shall be suitable for the intended use and shall be of metal.
Exceptions:
(1) (remaining text unchanged)
(3) Ducts used in central vacuum cleaning systems within a dwelling unit shall be constructed of materials in accordance with the applicable standards referenced in Chapter 17 ASTM F2158. Penetrations of fire walls or floor-ceiling or roof-ceiling assemblies shall be in accordance with the building code.

(remaining text unchanged)

506.2 Construction. Ducts used for conveying products shall be airtight construction as approved by the Authority Having Jurisdiction, and shall not have openings other than those required for operation and maintenance of the system. Ducts constructed of steel shall comply with Table 506.2(1) or Table 506.2(2).
Exceptions:
(1) (remaining text unchanged)
(2) Ducts used in central vacuuming systems within a dwelling unit shall be constructed of materials in accordance with the applicable standards referenced in Chapter 17 ASTM F2158. Penetrations of fire-resistive walls or floor-ceiling or roof-ceiling assemblies shall be in accordance with the building code. Copper or ferrous pipes or conduit extending from within the separation between a garage and dwelling unit to the central vacuum unit shall be permitted to be used.

(remaining text unchanged)

TABLE 1701.1
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>ASTM F2158-2008 (R2016)</td>
<td>Residential Central-Vacuum Tube and Fittings</td>
<td>Exhaust Systems</td>
<td>506.1, 506.2</td>
</tr>
</tbody>
</table>

(remaining text not shown remain unchanged)

Note: ASTM F2158 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.
TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM F2158-2008</td>
<td>Residential Central-Vacuum Tube and Fittings</td>
<td>Exhaust Systems</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:
In the 2018 edition of the UMC, Table 1701.1 has been split into two separate tables. Therefore, the existing reference to those tables must be revised to provide the proper standard for the applications. Section 506.1 and Section 506.2 are being revised to address the proper standard for central vacuum systems. This is necessary as the standards in Table 1701.2 must be approved by the AHU prior to their use.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is being rejected as there may be other standards that may apply.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NEGATIVE: 1

EXPLANATION OF NEGATIVE:
P. TRAFTON: I am in agreement with the Committee.
Item #: 034

UMC 2021 Section: 506.3

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

506.0 Product-Conveying Ducts.

506.3 Penetrations. Exhaust ducts shall not pass through fire walls, as defined by NFPA 221. [NFPA 91:4.2.11]

SUBSTANTIATION:
Section 506.3 should be revised as it is unnecessary to send the end user to NFPA 221 for a definition. The term “fire wall” is already defined in Chapter 2 of the UMC and it reads as follows: Fire Wall. A wall separating buildings or subdividing a building to prevent the spread of the fire and having a fire resistance rating and structural stability. [NFPA 96:3.3.26] The definition used in NFPA 221 for “fire wall” is as follows: 3.3.14.6* Fire Wall. A wall separating buildings or subdividing a building to prevent the spread of fire and having a fire resistance rating and structural stability. Therefore, it is apparent that both definitions read the same and it is unnecessary to send the user to a different document.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text deletion should remain as it is unnecessary to remove the NFPA 221 reference and NFPA 91 extract since they are needed for enforcement of the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NEGATIVE: 1

EXPLANATION OF NEGATIVE:

HEINE: It is unnecessary to remove the NFPA 221 reference as it is needed for enforcement.
Item #: 035

UMC 2021  Section: 507.1, 519.3

SUBMITTER: Mohamed Dano
Control Air Conditioning Corporation

RECOMMENDATION:
Revise text

507.0 General Requirements.
507.1 Type I Hood Exhaust System. Exhaust systems serving Type I hoods shall comply with Section 507.0 through Section 518.0. Exhaust systems serving Type II hoods shall comply with Section 519.0.

519.0 Type II Hood Exhaust System Requirements.

519.3 Type II Hood Exhaust System Net Airflow. The net airflow for Type II hoods shall be in accordance with Section 508.5.1.5 for light-duty cooking appliances. The net airflow for Type II hoods serving washing machines shall comply with Section 519.3.1.

519.3.1 Dishwashing Appliances. The net airflow for Type II hoods used for dishwashing equipment shall be not less than 200 cubic feet per minute (0.094 m$^3$/s) per linear foot (m) of hood length.

(renumber remaining sections)

SUBSTANTIATION:
Section 507.1 should be revised to clarify that Type II exhaust systems must comply with Section 519.0. Furthermore, Section 519.0 is being added as currently there is no guidance as to the required exhaust rate for Type II hoods. Section 508.5.1.5 applies to light-duty appliances. Section 508.5.1.5 states: The minimum net airflow for hoods used for cooking appliances such as gas and electric ovens (including standard, bake, roasting, revolving, retherm, convection, combination convection/steamer, rotisserie, countertop conveyorized baking/finishing, deck, and pastry), discrete element ranges (with or without oven), electric and gas steam-jacketed kettles less than 20 gallons (76 L), electric and gas pasta cookers, electric and gas compartment steamers (both pressure and atmospheric), electric and gas cheese melters, electric and gas tilting skillets (braising pans) electric and gas rotisseries, and electric and gas salamanders shall be in accordance with Table 508.5.1.5.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text does not assist the AHJ or installer in regards to Type II hoods.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 036

UMC 2021  Section: 508.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

508.0 Type I Hoods.
508.1 Where Required. Type I hoods shall be installed at or above commercial-type deep-fat fryers, broilers, grills, hot-top ranges, ovens, barbecues, rotisseries, and similar equipment that emits comparable amounts of smoke or grease in a food-processing establishment. For the purpose of this section, a food-processing establishment shall include a building or portion thereof used for the processing of food, but shall not include a dwelling unit.

Exceptions:
(1) Cooking appliance that is listed in accordance with UL 710B for reduced emissions where the grease discharge does not exceed 2.9 E-09 ounces per cubic inch (oz/in³) (5.0E-06 kg/m³) where operated with a total airflow of 500 cubic feet per minute (cfm) (0.236 m³/s).
(2) Recirculating systems listed in accordance with UL 710B and installed in accordance with Section 516.0.
(3) Downdraft appliance ventilation system listed and installed in accordance with Section 518.0.

SUBSTANTIATION:
A downdraft appliance ventilation system that has been listed and installed in accordance with Section 518.0 is already provided the minimum safety requirements for the exhaust of the smoke and grease, and thus does not require an additional Type I hood above.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Section 518.0 applies to downdraft appliances and it is not necessary to add downdraft appliances to Section 508.1 as an exception.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NEGATIVE: 1

EXPLANATION OF NEGATIVE:
KOERBER: I believe the proposal provides clarity. Also, I believe products should be "listed" where applicable, not just "in accordance with."
Item #: 037
UMC 2021 Section: 508.1

SUBMITTER: Kaveh Razavi
County of Los Angeles Building and Safety

RECOMMENDATION:
Revise text

508.0 Type I Hoods.

508.1 Where Required. Type I hoods shall be installed at or above commercial-type deep-fat fryers, broilers, grills, hot-top ranges, ovens, barbecues, rotisseries, and similar equipment that emits comparable amounts of smoke or grease in a food-processing establishment. For the purpose of this section, a food-processing establishment shall include a building or portion thereof used for the processing of food, but shall not include a dwelling unit.

Exceptions:

(1) A Type I hood shall not be required for a cooking appliance that is listed in accordance with UL 710B for reduced emissions where the grease discharge does not exceed 2.9E-09 ounces per cubic inch (oz/in³) (5.0E-06 kg/m³) where operated with a total airflow of 500 cubic feet per minute (cfm) (0.236 m³/s).

(2) Recirculating systems listed in accordance with UL 710B and installed in accordance with Section 516.0.

SUBSTANTIATION:
Section 508.1 (exception 1) is being revised as the exception 1 is creating confusion during plan check and in the field for Authority Having Jurisdictions. Many in the field are interpreting this section as excepting hoods altogether. However, this section only exempts the use of Type I hoods but not the use of Type II hoods. Type II hoods shall be required when excessive heat and/or steam is being emitted. UL 710B only tests hoods to be exempt from grease applications but not for excessive heat or steam such as bread ovens. In addition, exception 1 does not have language specifying that the cooking appliance must be "listed" in accordance with UL 710B, which is causing issues for Authority Having Jurisdictions. The words "listed" in accordance with..." should be used in exception 1 just like they are in exception 2.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is unnecessary as Section 508.0 already applies to Type I hoods as indicated by the title and language within the section.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 038
UMC 2021  Section: 510.4.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Delete text without substitution

510.0 Exhaust Duct Systems.

510.4 Listed Grease Ducts. (remaining text unchanged)
510.4.1 Factory-Built Grease Ducts. Factory-built grease ducts in accordance with UL 1978 shall be permitted to incorporate non-welded joints in accordance with their listings.

SUBSTANTIATION:
This is already covered in the exception to Section 510.5.3. Thus, Section 510.4.1 is redundant.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion is being rejected as the language is needed for enforcement of the code in regards to factory-built grease ducts.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 039
UMC 2021  Section: 510.5.5

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

510.0 Exhaust Duct Systems.

510.5 Other Grease Ducts. (remaining text unchanged)

510.5.5 Telescoping and Bell-Type Connections. For telescoping and bell-type connections, the inside duct section shall always be uphill of the outside duct section. [NFPA 96:7.5.5.3] The overlap shall not exceed 2 inches (51 mm) as shown in Figure 510.5.3.2(1).

SUBSTANTIATION:
Added “always” to match the NFPA extracted language and added reference to Figure 510.5.3.2(1) to clarify the connection.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD

EXPLANATION OF AFFIRMATIVE:
MACNEVIN: Is the proposed word “always” necessary code language? Doesn't “shall be” imply “always”?
Item #: 040

UMC 2021  Section: 510.9.1.1, 511.1.3.1(2)

SUBMITTER: Maria Yepremian  
County of Los Angeles Building and Safety

RECOMMENDATION:
Revise text

510.0 Exhaust Duct Systems.

510.9 Termination of Type I Hood Exhaust System. (remaining text unchanged)
510.9.1 Rooftop Terminations. (remaining text unchanged)
510.9.1.1 Listed Flexible Connectors. Listed flexible connectors shall be permitted to be used on exterior roof locations where required for proper equipment vibration isolation.

(renumber remaining sections)

511.0 Air Movement.
511.1 Exhaust Fans for Commercial Cooking Operations. (remaining text unchanged)

511.1.3 Utility Set Exhaust Fans. (remaining text unchanged)
511.1.3.1 At the Rooftop. Fans installed at the rooftop termination point shall be in accordance with the following:
(1) Section 510.9.1 and Section 510.9.1.2.
(2) Flexible connectors shall be prohibited.
(3) A drain shall be directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L).

SUBSTANTIATION:
Section 510.9.1.1 is being deleted as there currently is no listing for flexible connectors applicable for grease duct applications. Section 510.9.1.1 is creating problems for the AHJ as there currently is no guidance in the UMC as to what the acceptable listing for such flexible connector is. NFPA 96, which is the source document for the majority of provisions for commercial kitchen ventilation, prohibits the use of flexible connectors altogether per sections 8.1.3.3 and 8.1.4.5 of the 2017 edition. The UMC shall either provide the appropriate listing for flexible connectors or prohibit their use as they do in NFPA 96.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The current language is needed for clarification and direction to the AHJ and installer.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 041

UMC 2021  Section: 516.2.1

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

516.0 Recirculating Systems.

516.2 Design Restrictions. (remaining text unchanged)

516.2.1 Gas/Electrically Fueled Cooking Appliances. Gas-fueled or electrically fueled cooking appliances shall be used. Listed gas-fueled equipment designed for use with specific recirculating systems shall have the flue outlets connected in the intended manner. Gas-fueled appliances shall have not less than 18 inches (457 mm) of clearance from the flue outlet to the filter inlet in accordance with Section 509.2.2 through Section 509.2.2.3 and shall be in accordance with the installation requirements of NFPA 54 this Code or NFPA 58. [NFPA 96:13.2.1– 13.2.3]

SUBSTANTIATION:
It is not necessary to refer the end user to NFPA 54 as the UMC extracts the necessary requirements from NFPA 54 for gas and electric fueled cooking appliances. All the necessary appliances are addressed in Chapter 9 of the UMC. This currently creates confusion for inspectors.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion of the NFPA 54 reference would create confusion for the end user as it is part of the language extracted from NFPA 96.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 042
UMC 2021  Section: 519.5

SUBMITTER: Jeremy Martinez
Golden Gate Chapter ASHRAE
Rep: ASHRAE

RECOMMENDATION:
Revise text

519.0 Type II Hood Exhaust System Requirements.

519.5 Termination of Type II Hood Exhaust System. The exhaust system shall terminate as follows:
(1) Rooftop terminations shall terminate not less than 10 feet (3048 mm) from a property line, and the exhaust flow shall be directed away from the roof surface of the roof, not less than 40 inches (1016 mm)
(2) Horizontal terminations shall terminate not less than 10 feet (3048 mm) from adjacent buildings, property lines, operable openings, and from grade level.
(3) The termination outlet shall not be directed onto a public way.

SUBSTANTIATION:
Disallowing Type II exhaust to be onto a public way is onerous – urban restaurants often have only one wall and it is onto a public way so they have no other options. There is already a 10’ above grade limitation which is sufficient given Type II exhaust is generally just moist or hot air. Note that Type I exhaust terminations have no limitations relative to walkways and Type I exhaust is much more likely to be a nuisance due to odors and smoke.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 043

UMC 2021 Section: Chapter 5: 504.4.3.1

SUBMITTER: IAPMO Staff - Update Extracts
   NFPA 54 Extract Update

RECOMMENDATION:
Revise text

505.0 Product-Conveying Systems.

504.4 Clothes Dryers. (remaining text unchanged)

504.4.3.1 Exhaust Ducts for Type 2 Clothes Dryers. Exhaust ducts for Type 2 clothes dryers shall comply with the following:
(1) (remaining text unchanged)
(4) Exhaust ducts for unlisted Type 2 clothes dryers shall be installed with a minimum clearance of not less than 6 inches (152 mm) from adjacent combustible material. Where exhaust ducts for Type 2 clothes dryers are installed with reduced clearances, the adjacent combustible material shall be protected in accordance with Table 303.10.1. [NFPA 54:10.4.5.4]
(5) Where ducts pass through walls, floors, or partitions, the space around the duct shall be sealed with noncombustible material. [NFPA 54:10.4.5.5]
(6) Multiple installations of Type 2 clothes dryers shall be made in a manner to prevent adverse operation due to back pressures that are capable of being might be created in the exhaust systems. [NFPA 54:10.4.5.6] The exhaust fan shall operate continuously or shall be interlocked to exhaust air where a clothes dryer is in operation.

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Section 504.4.3.1 is being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
SUBMITTER: IAPMO Staff - Update Extracts
NFPA 96 Extract Update

RECOMMENDATION:
Revise text

507.0 General Requirements.
507.2 Exhaust System. Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system that is in accordance with all the equipment and performance requirements of this chapter. [NFPA 96:4.1.1] All such equipment and its performance shall be maintained in accordance with the requirements of this chapter during all periods of operation of the cooking equipment. [NFPA 96:4.1.2] The following equipment shall be kept in working condition:

1. Cooking equipment
2. Hoods
3. Ducts (where applicable)
4. Fans
5. Fire-extinguishing equipment
6. Special effluent or energy control equipment [NFPA 96:4.1.3]

Maintenence and repairs shall be performed on all components at intervals necessary to maintain good working conditions. [NFPA 96:4.1.3.1]

507.2.1 Airflow. All airflow shall be maintained. [NFPA 96:4.1.4]

507.2.2 Responsibility. The responsibility for inspection, testing, maintenance, and cleanliness of the ventilation control and fire protection of the commercial cooking operations, including cooking appliances, shall ultimately be that of the owner of the system, provided that this responsibility has not been transferred in written form to a management company, tenant, or other party. [NFPA 96:4.1.5]

507.2.3 Solid-fuel Cooking Equipment. All solid-fuel cooking equipment shall comply with the requirements of Section 517.0. [NFPA 96:4.1.6]

507.2.4 Multitenant Applications. Multitenant applications shall require the concerted cooperation of design, installation, operation, and maintenance responsibilities by tenants and by the building owner. [NFPA 96:4.1.7]

507.2.5 Interior Surfaces. All interior surfaces of the exhaust system shall be accessible for cleaning and inspection purposes. [NFPA 96:4.1.8]

507.2.6 Used in Other Applications. Cooking equipment used in fixed, mobile, or temporary concessions, such as trucks, buses, trailers, pavilions, tents, or a any form of roofed enclosure, shall be in accordance with this chapter unless otherwise exempted by the Authority Having Jurisdiction. [NFPA 96:4.1.9]

507.4 Factory Built. Factory-built grease duct enclosures shall be protected with a through-penetration firestop system classified in accordance with ASTM E814 or UL 1479 having an “F” and a “T” rating equal to the fire resistance rating of the assembly being penetrating from the point at which the duct penetrates a ceiling, wall, or floor to the outlet terminal. [NFPA 96:4.3.3]

507.4.4.1 Listing. The factory-built grease duct protection system shall be listed in accordance with UL 2221. [NFPA 96:4.3.3.1]

507.4.4.2 Single Wall. Listed single wall factory-built grease ducts shall be permitted to be enclosed with field-applied grease duct enclosure material where the material and the assembly of duct and material are listed for that application and installed in accordance with the grease duct manufacturer’s listing and their installation instructions. [NFPA 96:4.3.3.2]

507.4.4.3 Installation. The factory-built grease duct system shall be installed in accordance with the manufacturer’s installation instructions and the listing requirements. [NFPA 96:4.3.3.3]

508.0 Type I Hoods.
508.2 Listed Type I Hood Assemblies. Listed hood assemblies shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions. Listed hood assemblies shall be tested in accordance with UL 710 or equivalent. [NFPA 96:5.4.1, 5.4.2]

508.2.1 Listed Ultraviolet Hoods. Listed ultraviolet hoods shall be installed and maintained in accordance with the terms of their listing and the manufacturer’s installation instructions. Duct systems connected to ultraviolet hoods shall comply with Section
510.0. Ultraviolet hoods shall be tested and listed in accordance with UL 710 and UL 710C. [NFPA 96:5.5-5.5.2]

507.4.4.3 Listed Ventilated Ceiling Technology. Listed ventilated ceiling technology shall be installed and maintained in accordance with the terms of its listing and the manufacturer's instructions. [NFPA 96:5.6]

(renumber remaining sections)

508.3 Construction of Type I Hoods. The hood or that portion of a primary collection means designed for collecting cooking vapors and residues shall be constructed of and be supported by steel not less than 0.048 of an inch (1.219 mm) (No. 18 MSG), stainless steel not less than 0.036 of an inch (0.914 mm) (No. 20 MSG) in thickness, or other approved material of equivalent strength and fire and corrosion resistance. [NFPA 96:5.1.1]

Exception: Listed exhaust hoods.

509.0 Grease Removal Devices in Hoods.

509.1 Grease Removal Devices. Listed grease filters or other listed grease removal devices intended for use with commercial cooking operations shall be provided. Listed grease filters and grease removal devices that are removable, but not an integral component of a specific listed exhaust hood, shall be listed in accordance with ANSI/UL 1046 and shall be designated on the filter. [NFPA 96:6.1.1, 6.1.2]

509.2.1 Vertical Distance. Where grease removal devices are used in conjunction with charcoal or solid fuel-type broilers, including gas or electrically heated charbroilers, a minimum vertical distance of not less than 4 feet (1219 mm) shall be maintained between the lower edge of the grease removal device and the cooking surface. [NFPA 96:6.2.1.2]

Exceptions:

1. For cooking equipment without exposed flame and where flue gases bypass grease removal devices, the minimum vertical distance shall be permitted to be reduced to not less than 6 inches (152 mm). [NFPA 96:6.2.1.3]
2. Where a grease removal device is listed for separation distances less than those required in Section 509.2 and Section 509.2.1, the listing requirements shall be permitted. [NFPA 96:6.2.1.4]
3. Grease removal devices supplied as part of listed hood assemblies shall be installed in accordance with the terms of the listing and the manufacturer's installation instructions. [NFPA 96:6.2.1.5]

509.2.3.1 Arrangement. Grease filters shall be arranged so that all exhaust air passes through the grease filters. [NFPA 96:6.2.3.4]

509.2.4.1 Size and Pitch. Grease drip trays shall be kept to the minimum size needed to collect grease. Grease drip trays and shall be pitched to drain into an enclosed metal container having a capacity not exceeding 1 gallon (4 L). [NFPA 96:6.2.4.2, 6.2.4.3]

509.2.5 Grease Filter Orientation. Grease filters that require a specific orientation to drain grease shall be clearly so designated on the face of the filter as to be visible with the filter installed, or the hood or filter shall be constructed so that filters cannot be installed in the wrong orientation. [NFPA 96:6.2.5]

510.0 Exhaust Duct Systems.

510.1.2 Interconnection. Duct systems shall not be interconnected with a any other building ventilation or exhaust system. [NFPA 96:7.1.3]

510.1.3 Duct Installation. All ducts shall be installed with not less than a minimum 2 percent slope on horizontal runs up to 75 feet (22 860 mm) and not less than a minimum 8 percent slope on horizontal runs more greater than 75 feet (22 860 mm). Factory-built grease ducts shall be permitted to be installed at a lesser slope in accordance with the listing and the manufacturer’s installation instructions. All horizontal ducts shall be provided with access in accordance with Section 510.3.3. Drains shall be provided at low points in horizontal ducts. Where provided, drains shall be continuously welded to the exhaust duct or listed grease duct drains in accordance with the terms of the listing and the manufacturer’s installation instructions manual. All ducts shall be installed without forming dips or traps. In manifold (common duct) systems, the lowest end of the main duct shall be connected flush on the bottom with the branch duct. [NFPA 96:7.1.4 – 7.1.4.5]

510.1.5 Sign. A sign stating the following shall be placed on all access panels stating the following: ACCESS PANEL – DO NOT OBSTRUCT [NFPA 96:7.1.6]

510.1.7 Type I Exhaust Duct Systems. Listed grease ducts shall be installed in accordance with the terms of their listings and manufacturer’s installation instructions. [NFPA 96:7.1.7]

510.3.4.2 Safe Access and Work Platform. Where If not easily accessible from the floor or a 10 foot (3048 mm) stepladder, openings on vertical grease ducts shall be provided with safe access and a work platform. [NFPA 96:7.4.2.3]

510.3.6 Access Panels. Access panels shall be of the same material and thickness as the duct. Access panels shall have a gasket or sealant that is rated for 1500°F (816°C) and shall be greaseltight. Fasteners, such as bolts, weld studs, latches, or wing nuts, used to secure the access panels shall be carbon steel or stainless steel and shall not penetrate duct walls. [NFPA 96:7.4.3.1-7.4.3.3]

Exception: 510.3.6.1 Listed Grease Ducts. Listed grease duct access door assemblies (access panels) shall be installed in accordance with the terms of the listings and the manufacturer’s installation instructions. [NFPA 96:7.4.3 7.4.3.4]
510.4 Listed Grease Ducts. Listed grease ducts shall be installed in accordance with the terms of the listing and the manufacturer’s installation instructions. [NFPA 96:7.1.7]

510.5.5 Telescoping and Bell-Type Connections. For telescoping and bell-type connections, the inside duct section shall always be uphill of the outside duct section. [NFPA 96:7.5.5.3]

510.7 Interior Installations. In all buildings more than one story in height, and in one-story buildings where the roof-ceiling assembly is required to have a fire resistance rating, the ducts shall be enclosed in a continuous enclosure extending from the lowest fire-rated ceiling or floor above the hood, through any concealed spaces, to or through the roof, to maintain the integrity of the fire separations required by the applicable building code provisions. The enclosure shall be sealed around the duct at the point of penetration of the first fire-rated barrier after the hood, to maintain the fire resistance rating of the enclosure. The enclosure shall be vented to the exterior of the building through weather-protected openings. [NFPA 96:7.7.1.2 – 7.7.1.4]

Exception: The continuous enclosure provisions shall not be required where a field-applied grease duct enclosure or a factory-built grease duct enclosure (see Section 507.4.4 through Section 507.4.6) is protected with a listed duct-through-penetration protection system equivalent to the fire resistance rating of the assembly being penetrated, and where the materials are installed in accordance with the conditions of the listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.1.5]

510.7.3 Clearance. Clearance from the duct or the exhaust fan to the interior surface of enclosures of combustible construction shall be not less than 18 inches (457 mm), and Clearance from the duct to the interior surface of enclosures of noncombustible or limited-combustible construction shall be not less than 6 inches (152 mm). Provisions for reducing clearances as described in Section 507.4 through Section 507.4.3.3 shall not be applicable to enclosures. [NFPA 96:7.7.2.2.1 – 7.7.2.2.3]

Exception: Clearance from the outer surfaces of field-applied grease duct enclosures and factory-built grease duct enclosures to the interior surfaces of construction installed around them shall be permitted to be reduced where the field-applied grease duct enclosure materials and the factory-built grease duct enclosures are installed in accordance with the conditions of the listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.2.2.4]

510.7.4 Mechanical and Structural Integrity. Field-applied grease duct enclosures and factory-built grease duct enclosures shall provide mechanical and structural integrity, resiliency, and stability when subjected to expected building environmental conditions, duct movement under general operating conditions, and duct movement as a result of interior and exterior fire conditions. [NFPA 96:7.7.2.2.5]

510.7.5.1 Protection from Physical Damage. Measures shall be taken to prevent physical damage to a any covering or enclosure material. Damage Any damage to the covering or enclosure shall be repaired, and the covering or enclosure shall be restored in accordance with its intended listing and fire resistance rating, and to be acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.1, 7.7.3.2]

510.7.5.2 Inspection. In the event of a fire within a kitchen exhaust system, the duct, the enclosure, and the covering directly applied to the duct shall be inspected by qualified personnel to determine whether the duct, the enclosure, and the covering directly applied to the duct are structurally sound, capable of maintaining their fire protection functions, approved suitable for continued operation, and acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.3]

510.7.7 Fire Doors. Where openings in the enclosure walls are provided, they shall be protected by listed fire doors of proper rating. Fire doors shall be installed in accordance with NFPA 80. Openings on other listed materials or products shall be clearly identified and labeled according to the terms of the listing and the manufacturer’s instructions and shall be acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.4.1 – 7.7.4.3] The fire door shall be readily accessible, aligned, and of a sufficient size to allow access to the rated access panels on the ductwork. [NFPA 96:7.7.4.4]

510.7.8 Ducts with Enclosure(s). AEach duct system shall constitute an individual system serving only exhaust hoods in one fire zone on one floor. Multiple ducts shall not be permitted in a single enclosure unless acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.5 – 7.7.5.2]

510.9.1 Rooftop Terminations. Rooftop terminations shall be arranged with or provided with the following:

1. Not less than A minimum of 10 feet (3048 mm) of horizontal clearance from the outlet to adjacent buildings, property lines, and air intakes.
2. Not less than A minimum of 5 feet (1524 mm) of horizontal clearance from the outlet (fan housing) to a any combustible structure.
3. A vertical separation of 3 feet (914 mm) below an exhaust outlet for above any air intakes within 10 feet (3048 mm) of the exhaust outlet.
4. The ability to drain grease out of traps or low points formed in the fan or duct near the termination of the system into a collection container that is noncombustible, closed, rainproof, and structurally sound for the service to which it is applied, and that will not sustain combustion.
5. A grease collection device that is applied to exhaust systems that does not inhibit the performance of a any fan.
6. A listed grease collection systems that is in accordance with meet the requirements of Section 510.9.1(4) and Section 510.9.1(5).
(7) A listed grease duct complying with Section 507.4.7 or ductwork complying with Section 507.4.8.
(8) A hinged upblast fan supplied with flexible weatherproof electrical cable and service hold-open retainer to permit inspection and cleaning that is listed for commercial cooking equipment with the following conditions:
   (a) Where the fan attaches to the ductwork, the ductwork is not less than a minimum of 18 inches (457 mm) away from any roof surface, as shown in Figure 510.9.1.
   (b) The fan discharges not less than a minimum of 40 inches (1016 mm) away from any roof surface, as shown in Figure 510.9.1.
(9) Other approved fan, provided it meets all of the following criteria:
   (a) The fan meets the requirements of Section 510.9.1(3) and Section 511.1.3.
   (b) Its discharge or its extended duct discharge meets with the requirements of Section 510.9.1(2). (See Section 511.1.3)
   (c) Exhaust fan discharge is directed up and away from the roof surface. [NFPA 96:7.8.2.1]

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

Notes:
1. Fresh air intake (FAI) applies to an air intake, including an operable door or window.
2. Example:
   (a) FAIs 1 and 5 are on the same plane as exhaust or lower: 10 feet (3048 mm) min. between closest edges.
   (b) FAIs 2, 3, and 4 are above plane of exhaust fan:
      10 feet + 3 inches 0.25 feet (3048 mm + 76 mm) per degree between closest edges.

**FIGURE 510.9.2**

EXHAUST TERMINATION DISTANCE FROM FRESH AIR INTAKE (FAI) OR OPERABLE DOOR OR WINDOW

[NFPA 96: FIGURE 7.8.3]

511.0 Air Movement.
511.1 Exhaust Fans for Commercial Cooking Operations. (remaining text unchanged)
511.1.2.1 Accessibility. Where the design or positioning of the fan allows grease to be trapped, a drain directed to a readily accessible and visible grease receptacle, not exceeding 1 gallon (4 L), shall be provided. In-line exhaust fans shall be located in an easily accessible area of adequate size to allow for service or removal. Where the duct system connected to the fan is in an enclosure, the space or room in which the exhaust fan is located shall have the same fire resistance rating as the enclosure. [NFPA 96:8.1.3.4 – 8.1.3.6]

511.2.3 Exhaust Fan Operation. A hood exhaust fan(s) shall continue to operate after the extinguishing system has been activated, unless fan shutdown is required by a listed component of the ventilation system, or by the design of the extinguishing system. The hood exhaust fan shall not be required to start upon activation of the extinguishing system if the exhaust fan and all cooking equipment served by the fan have been shut down, unless fan shutdown is required by a listed component of the ventilation system or by the listing of the extinguishing system. The exhaust fan shall be provided with a means so that the fan is activated when any heat-producing cooking appliance under the hood is turned on. [NFPA 96:8.2.3.1-8.2.3.3]
512.0 Auxiliary Equipment.

512.2 Electrical Equipment. Wiring systems of any type shall not be installed in ducts. [NFPA 96:9.2.1]

512.2.1 Device Installation in Ducts. Motors, lights, and other electrical devices shall be permitted to be installed in ducts or hoods or to be located in the path of travel of exhaust products only where specifically listed for such use. [NFPA 96:9.2.2]

512.2.2 Lighting Units. Lighting units in on hoods shall not be located in concealed spaces except as permitted by Section 512.2.3 and Section 512.2.4. [NFPA 96:9.2.3.2]

512.3 Other Equipment. Fume incinerators, thermal recovery units, air pollution control devices, or other devices shall be permitted to be installed in ducts, or hoods or to be located in the path of travel of exhaust products where specifically listed for such use. [NFPA 96:9.3.1]

512.3.1 Access Required. Equipment shall have space provided to all access panels or doors for the safe removal and servicing of control devices, such as filters, electrostatic precipitator cells, and odor control media beds, and for cleaning of the equipment housing. [NFPA 96:9.3.1.3]

512.3.2 Downgrading. Downgrading other parts of the exhaust system due to the installation of these approved devices, whether listed or not, shall not be permitted allowed. [NFPA 96:9.3.1, 9.3.2]

512.3.4 512.3.3 Fire-Extinguishing System. An Any equipment, listed or otherwise, installed in the path of exhaust products that provides secondary filtration or air pollution control and that is installed in the path of travel of exhaust products shall be provided with an approved automatic fire-extinguishing system, installed in accordance with the fire-extinguishing system manufacturer’s installation instructions, for the. [NFPA 96:9.3.3]

512.3.3 Protection. The fire-extinguishing system required by Section 512.3.3 shall provide protection of for the component sections of the equipment, and shall include protection of the ductwork downstream of the equipment, whether or not the equipment is provided with a damper. [NFPA 96:9.3.3.1]

512.3.3.2 Filter Media. Filter media used in secondary filtration or air pollution control units and not in accordance complying with Section 509.2.3 shall have fire protection that is adequate for the filter media being used in accordance with the fire-extinguishing system manufacturer’s instructions. [NFPA 96:9.3.3.2]

512.3.4 Source of Ignition. Where If the equipment provides a source of ignition, it shall be provided with a detection to operate the fire-extinguishing system protecting the equipment. [NFPA 96:9.3.3.2 – 9.3.4]

512.3.5 Air Recirculation. Where a cooking exhaust system employs an air pollution control device that recirculates air into the building, the requirements of Section 516.0 shall apply. [NFPA 96:9.3.5]

512.3.6 Carbon Monoxide Required. If the heat source is non-electric and open flames are used, a carbon monoxide detector shall be installed in both the kitchen and dining areas. [NFPA 96:9.3.7]

513.0 Fire-Extinguishing Equipment.

513.1 General. (remaining text unchanged)

513.1.1 Devices in Exhaust Ducts. Fume incinerators, thermal recovery units, air pollution control devices, or other devices installed in the exhaust duct shall be protected by an automatic fire-extinguishing system. [NFPA 96:10.1.3]

513.2.1 Identification. A placard shall be conspicuously placed near the fire each Class K extinguisher that states that the fire protection system shall be activated prior to using the fire-extinguisher. [NFPA 96:10.2.2]

513.2.5 Fixed Baffle Hoods with Water Wash. Grease removal devices, hood exhaust plenums, and exhaust ducts Areas requiring protection in accordance with Section 513.1 shall be permitted to be protected by a listed fixed baffle hood containing a constant or fire-actuated water-wash system that is listed and as a fire-extinguishing system in accordance compliance with UL 300 or other equivalent standards and shall be installed in accordance with the requirements of their its listing. [NFPA 96:10.2.8.1]

513.2.5.1 Listed for the Purpose. Each such area not provided with a listed water-wash fire-extinguishing system shall be provided with a fire-extinguishing system listed for the purpose. [NFPA 96:10.2.8.2]

513.2.5.5 Water-Wash System. A water-wash system approved to be used for protection of the grease removal device(s), hood exhaust plenum(s), exhaust duct(s), or combination thereof shall include instructions and appropriate electrical interface for simultaneous activation of the water-wash system from an automatic fire-extinguishing system, where the automatic fire-
extinguishing system is used for cooking equipment protection only. [NFPA 96:10.2.8.6]

513.2.5.5 Exception. Where the automatic fire-extinguishing system in accordance with NFPA 17A provides protection for the cooking equipment, hood, and duct, activation of in a fixed baffle hood containing a water-wash system, the water-wash system shall not be required made inoperable or delayed for a minimum of 60 seconds upon operation of the automatic fire-extinguishing system. [NFPA 96:10.2.8.7]

513.2.5.6 Water Supply. The water required for listed automatic fire-extinguishing systems shall be permitted to be supplied from the domestic water supply where the minimum water pressure and flow are provided in accordance with the terms of the listing. The water supply shall be controlled by a supervised water supply control valve. Where the water supply is from a dedicated fire protection water supply in a building with one or more fire sprinkler systems, separate indicating control valves and drains shall be provided and arranged so that the hood system and sprinkler system are capable of being systems can be controlled individually. [NFPA 96:10.2.9.1, 10.2.9.2]

513.2.6 Water Valve Supervision. Valves controlling the water supply to listed fixed baffle hood assemblies water-wash fire-extinguishing systems, automatic fire-extinguishing systems, or both shall be listed indicating type of valve and shall be supervised open by one of the following methods:

1. Central station, proprietary, or remote station alarm service.
2. Local alarm service that will cause the sounding of an audible signal at a constantly attended point.
3. Locking valves open.
4. Sealing of valves and approved weekly recorded inspection. [NFPA 96:10.2.10]

513.3 Simultaneous Operation. Fixed pipe extinguishing systems in a single hazard area shall be arranged for simultaneous automatic operation upon actuation of any one of the systems. [NFPA 96:10.3.1]

513.3.1 Hoods. Hoods installed end to end, back to back, or both, or sharing a common ductwork, not exceeding 75 feet (22 860 mm) in distance from the farthest hood, and having a grease producing appliance(s) located under one or more of the hoods, shall be considered a single hazard area requiring simultaneous automatic fire protection in all hoods and ducts. [NFPA 96:10.3.1.1]

513.3.1.1 Common Ductwork. In hoods that are installed end to end, back to back, or both, and that share a common ductwork, the ductwork beyond 75 feet (22 860 mm) from the farthest hood shall be protected by an independent fire-extinguishing system with its own detection system or by a fire-extinguishing system that activates simultaneously with the fire-extinguishing system(s) protecting the hoods. [NFPA 96:10.3.1.1.1]

513.3.2 Independent Systems. Hoods installed end to end, back to back, or both that do not share a common exhaust duct and are separated by a wall(s) or other means to ensure that grease-laden vapors exhausted under one hood cannot propagate to the other hoods, the hoods’ fire-extinguishing system(s) shall be independent and shall not be required to simultaneously discharge. [NFPA 96:10.3.1.2]

513.3.3 Exempt Equipment. Fume incinerators, thermal recovery units, air pollution control devices, or other devices installed in the exhaust duct shall not be required to comply with Section 513.3.1. [NFPA 96:10.3.1.3]

(renumber remaining sections)

513.3.1 Automatic Sprinkler System. Simultaneous operation shall not be required where the one fixed pipe extinguishing system is an automatic sprinkler system. Where an automatic sprinkler system is used in conjunction with a water-based fire-extinguishing system served by the same water supply, hydraulic calculations shall consider both systems operating simultaneously. [NFPA 96:10.3.2, 10.3.2.1]

513.3.2 Dry or Wet Chemical Systems. Simultaneous operation shall be required where a dry or wet chemical system is used to protect common exhaust ductwork by one of the methods specified in NFPA 17 or NFPA 17A. [NFPA 96:10.3.3]

513.4.1 Steam. Steam supplied from an external source shall not be required to automatically shut off. [NFPA 96:10.4.2]

513.5 Manual Activation. All systems shall have both automatic and manual methods of actuation. At least one manual actuation device shall be located in a means of egress or at a location acceptable to the Authority Having Jurisdiction.

The manual actuation device shall clearly identify the hazard protected. An automatic sprinkler system shall not require a method of manual actuation.

A readily accessible means for manual activation shall be located between 42 inches and 48 inches (1067 mm and 1219 mm) above the floor, be accessible in the event of a fire, be located in a path of egress, and clearly identify the hazard protected. Not less than one manual actuation device shall be located not less than 10 feet (3048 mm) and not more than 20 feet (6096 mm) from the protected exhaust system(s) within the path of egress or at an alternative location acceptable to the Authority Having Jurisdiction.

Manual activation using a cable-operated pull station shall not require more than 40 pounds-force (178 N) of force, with a pull movement not to exceed 14 inches (356 mm) to activate the automatic fire-extinguishing system. The automatic and manual means of system activation external to the control head or releasing device shall be separate and independent of each other so that failure of one will not impair the operation of the other except as permitted in Section 513.5.4. [NFPA 96:10.5.1 – 10.5.2]
513.5.3 Manual Actuator(s). The means for manual activation shall be mechanical or rely on electrical power for activation in accordance with Section 513.5.4. [NFPA 96:10.5.5]

513.5.4 Standby Power Supply. Electrical power shall be permitted to be used for manual activation where a standby power supply is provided or where supervision is provided in accordance with Section 513.7. [NFPA 96:10.5.6]

513.7 System Supervision. Where electrical power is required to operate the fixed automatic fire-extinguishing system, the system shall be provided with a reserve power supply and be monitored by a supervisory alarm except as permitted in accordance with Section 513.7.1. [NFPA 96:10.7.1]

513.7.1 Automatic Fire-Extinguishing System. Where a fixed automatic fire-extinguishing system includes automatic mechanical detection and actuation as a backup detection system, electrical power monitoring, and reserve power supply shall not be required. [NFPA 96:10.7.2]

513.7.2 Supervision. System supervision shall not be required where a fire-extinguishing system(s) is interconnected or interlocked with the cooking equipment power source(s) so that where the fire-extinguishing system becomes inoperable due to power failure, sources of fuel or electric power that produce heat to cooking equipment serviced by that hood shall automatically shut off. [NFPA 96:10.7.3]

513.7.3 Listed Water Wash System. System supervision shall not be required where an automatic fire extinguishing system, including automatic mechanical detection and actuation, is electrically connected to a listed fire-actuated water wash system for simultaneous operation of both systems. [NFPA 96:10.7.4]

513.8 Special Design and Application. Hoods containing automatic fire-extinguishing systems are protected areas; therefore, these hoods are not to be considered obstructions to overhead sprinkler systems and shall not require floor additional sprinkler coverage underneath. [NFPA 96:10.8.1]

513.8.1 Single Device. A single detection device, listed with the extinguishing system, shall be permitted for more than one appliance where installed in accordance with the terms of the listing. [NFPA 96:10.8.2]

513.10 Installation Requirements. Installation of systems shall be performed only by persons properly trained and qualified to install the specific system being provided. The installer shall provide certification to the Authority Having Jurisdiction that the installation is in accordance with the terms of the listing and the manufacturer’s installation instructions, and/or approved design, or both. [NFPA 96:10.9.2 10.8.2.1 10.8.2.2]

513.11 Portable Fire Extinguishers. Portable fire extinguishers shall be selected and installed in kitchen cooking areas in accordance with NFPA 10 and shall be specifically listed for such use. Class K fire extinguishers shall be provided for cooking appliances hazards that involve combustible cooking media such as (vegetable oils, and animal oils, and fats). [NFPA 96:10.10.4 10.10.2 10.9.1 10.9.2]

513.11.1 Other Fire Extinguishers. Portable fire extinguishers shall be provided for other hazards in kitchen areas and shall be selected and installed in accordance with NFPA 10. [NFPA 96:10.10.3 10.9.3]

513.11.2 Carbon Dioxide-Type. Carbon dioxide-type extinguishers shall not be permitted. [NFPA 96:10.9.4]

514.0 Procedures for the Use, Inspection, Testing, and Maintenance of Equipment.

514.1 Operating Procedures. Exhaust systems shall be operated whenever cooking equipment is turned on. [NFPA 96:11.1.1]

514.1.6 Secondary Control Equipment. Secondary filtration and pollution control equipment shall be operated in accordance with the terms of its listing and the manufacturer’s instructions recommendations. [NFPA 96:11.1.7]

514.1.7 Inspection Frequency. Inspection and maintenance of “other equipment” as allowed in Section 512.3 shall be conducted by properly trained and qualified persons at a frequency determined by the manufacturer’s instructions or the equipment listing. [NFPA 96:11.1.8]

514.2 Inspection, Testing, and Maintenance. Maintenance of the fire-extinguishing systems and listed exhaust hoods containing a constant or fire-activated water system that is listed to extinguish a fire in the grease removal devices, hood exhaust plenum, and exhaust ducts shall be made by properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction not less than every 6 months. [NFPA 96:11.1.2.1]

514.2.1 Requirements. Actuation All actuation and control components, including remote manual pull stations, mechanical and electrical devices, detectors, and actuators, shall be tested for proper operation during the inspection in accordance with the manufacturer’s instructions procedures. The specific inspection and maintenance requirements of the extinguishing system standards as well as the applicable installation and maintenance manuals for the listed system and service bulletins shall be followed. [NFPA 96:11.2.2 11.2.3]

514.2.2 Fusible Links and Sprinklers. Fusible links of the metal alloy type and automatic sprinklers of the metal alloy type shall be replaced not less than every 6 months except as permitted by Section 514.2.3 and Section 514.2.4. [NFPA 96:11.2.4]

514.2.4 Temperature-Sensing Elements. Fixed temperature-sensing elements other than the fusible metal alloy type shall be permitted to remain continuously in service, provided they are inspected and cleaned, or replaced where necessary in accordance with the manufacturer’s instructions, every 12 months or more frequently to ensure proper operation of the system. [NFPA 96:11.2.7]

514.3 Inspection for Grease Buildup. The entire exhaust system shall be inspected for grease buildup by a properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction and in accordance with Table 514.3. [NFPA 96:11.4]
TABLE 514.3
SCHEDULE OF INSPECTION FOR GREASE BUILDUP
[NFPA 96: TABLE 11.4]

<table>
<thead>
<tr>
<th>TYPE OR VOLUME OF COOKING</th>
<th>INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems serving solid-fuel cooking operations.</td>
<td>Monthly</td>
</tr>
<tr>
<td>Systems serving high-volume cooking operations such as 24-hour cooking, charbroiling, or wok cooking.</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Systems serving moderate-volume cooking operations.</td>
<td>Semiannually</td>
</tr>
<tr>
<td>Systems serving low-volume cooking operations, such as churches, day camps, seasonal businesses, or senior centers.</td>
<td>Annually</td>
</tr>
</tbody>
</table>

Notes:
1 High-volume cooking operations include 24-hour cooking, charbroiling, and wok cooking.
2 Low-volume cooking operations include churches, day camps, seasonal businesses, and senior centers.

514.4 Cleaning of Exhaust Systems. Where, upon inspection, the exhaust system is found to be contaminated with deposits from grease-laden vapors, the contaminated portions of the exhaust system shall be cleaned by a properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.6.1]

514.4.1 Measurement System. A measurement system of deposition shall be established to trigger a need to clean when the exhaust system is inspected at the frequencies in Table 514.3. [NFPA 96:11.6.1.1]

514.4.1.1 Combustible Contaminants. Hoods, grease removal devices, fans, ducts, and other appurtenances shall be cleaned to remove combustible contaminants to a minimum of 0.002 of an inch (50 um). [NFPA 96:11.6.1.1.1]

514.4.1.2 Gauge Comb. A grease depth gauge comb as shown in Figure 514.4.1.2 shall be placed upon the surface to measure grease depth. [NFPA 96:11.6.1.1.2]

![Depth Gauge Comb](https://via.placeholder.com/150)

**FIGURE 514.4.1.2**
Depth Gauge Comb
[NFPA 96: Figure 11.6.1.1.2]

514.4.1.3 Cleaning Method. Where a measured depth of 0.078 of an inch (2000µm) is observed, the surfaces shall be cleaned in accordance with Section 514.4. [NFPA 96:11.6.1.1.3]
514.4.1.4 Combustible Contaminants. Where a measured depth of 0.125 of an inch (3175 µm) is observed in a fan housing, the surfaces shall be cleaned in accordance with Section 514.4. [NFPA 96:11.6.1.1.4]

514.4.4 Inoperable. Fire-extinguishing systems shall be permitted to be rendered inoperable during the cleaning process where serviced by properly trained and qualified persons. [NFPA 96:11.6.5]

514.4.8 Access Panels and Cover Plates. Where cleaning procedures are completed, all access panels (doors) and cover plates shall be restored to their normal operational condition. [NFPA 96:11.6.9]

514.4.9 Date of Inspection. When an access panel is removed, a service company label or tag preprinted with the name of the company and giving the date of inspection or cleaning shall be affixed near the affected access panels. [NFPA 96:11.6.10]

514.4.11 Operable State. When cleaning procedures are completed, all electrical switches and system components shall be returned to an operable state. [NFPA 96:11.6.12]

514.4.12 Certification of Service. When an exhaust cleaning service is used, a certificate showing the name of the servicing company, the name of the person performing the work, and the date of inspection or cleaning shall be maintained on the premises. [NFPA 96:11.6.13]

514.4.15 Metal Containers. Metal containers used to collect grease drippings shall be inspected or emptied at least weekly. [NFPA 96:11.6.16]

515.0 Minimum Safety Requirements for Cooking Equipment.

515.1 Cooking Equipment. Listed appliances shall be installed in accordance with the terms of their listings and the manufacturer’s installation instructions. Solid fuel used for flavoring within a gas-operated appliance shall be in a solid fuel holder (smoker box) that is listed with the equipment. [NFPA 96:12.1.2.1, 12.1.2.1.1]

515.1.2 Prior Location. The fire-extinguishing system shall not require re-evaluation where the cooking appliances are moved for the purposes of maintenance and cleaning, provided the appliances are returned to approved design location prior to cooking operations, and any disconnected fire-extinguishing system nozzles attached to the appliances are reconnected in accordance with the manufacturer’s instructions and listing listed design manual. [NFPA 96:12.1.2.3]

516.0 Recirculating Systems.

516.1 General Requirements. Recirculating systems containing or for use with appliances used in processes producing smoke or grease-laden vapors shall be equipped with components in accordance complying with the following:

(1) The clearance requirements of Section 507.4.
(2) The A hood shall comply complying with the requirements of Section 508.0.
(3) Grease removal devices shall comply complying with Section 509.0.
(4) The air movement requirements of Section 511.2.1 and Section 511.2.2.
(5) Auxiliary equipment (such as particulate and odor removal devices) shall comply complying with Section 512.0.
(6) Fire-extinguishing equipment shall comply complying with the requirements of Section 513.0.

Exception: Fire-extinguishing equipment in accordance with Section 513.1 and Section 513.5.

(7) The use and maintenance requirements of Section 514.0.
(8) The minimum safety requirements of Section 515.0.
(9) The All the requirements of Section 516.0. [NFPA 96:13.1]
(10) Provisions shall be provided for latent heat and excessive moisture acceptable to the Authority Having Jurisdiction.

516.2.9 Listing Evaluation. Listing evaluation shall include the following:

(1) Capture and containment of vapors at published and labeled airflows.
(2) Grease discharge at the exhaust outlet of the system not to exceed an average of 2.9 E-09 (oz/in^3) (5.0 E-06 kg/m^3) of exhausted air sampled from that equipment at maximum amount of product that is capable of being processed over a continuous 8 hour test per EPA Test Method 202, with the system operating at its minimum listed airflow.
(3) Listing and labeling of clearance to combustibles from the all sides, top, and bottom.
(4) Electrical connection in the field in accordance with NFPA 70.
(5) Interlocks on all removable components that lie in the path of airflow within the unit to ensure that they are in place during operation of the cooking appliance. [NFPA 96:13.2.12]

516.3.4 Airflow Switch or Transducer. An airflow switch or transducer shall be provided after the last filter component to ensure that a minimum airflow is maintained. The airflow switch or transducer shall open the interlock circuit where when the airflow falls 25 percent below the system’s normal operating flow or 10 percent below its listed minimum rating, whichever is lower. The airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:13.3.5.1 – 13.3.5.3]
516.5 Additional Fire Safety Requirements. In addition to the appliance nozzle(s), a recirculating system shall be listed with the appropriate fire protection for grease filters, grease filtration, odor filtration units, and ductwork, where applicable. [NFPA 96:13.5.1]

516.6.2 Cleaning Schedule. All ESPs shall be cleaned a minimum of once per week and in accordance with according to the manufacturer’s cleaning instructions. [NFPA 96:13.6.3]

516.6.3 Hood Plenum and Blower Section Cleaning Schedule. The entire hood plenum and the blower section shall be cleaned not less than a minimum of once every 3 months. [NFPA 96:13.6.4]

516.6.4 Inspection of Safety Interlocks. Inspection and testing of the total operation and all safety interlocks in accordance with the manufacturer’s instructions shall be performed by qualified service personnel not less than a minimum of once every 6 months, or more frequently where if required. [NFPA 96:13.6.5]

517.0 Solid-Fuel Cooking Operations.
517.3 Hoods for Solid-Fuel Cooking. (remaining text unchanged)
517.3.1 Separation. (remaining text unchanged)
517.3.1.1 Equipment with Solid Fuel for Flavoring. Gas-operated equipment utilizing solid fuel for flavoring that is in accordance with meets all the following conditions shall not have to have a separate exhaust system:
(1) The solid fuel holder (smoker box) shall be listed with the gas-operated equipment.
(2) The solid fuel holder shall be located underneath the gas burners.
(3) Spark arresters that are in accordance conforming with Section 517.1.6 shall be provided.
(4) The maximum quantity of solid fuel consumed shall not exceed 4.5 pounds per hour per 100 000 Btu/hr (29 kW) of gas burner capacity.
(5) The gas-operated equipment shall be protected by a fire suppression system listed for the equipment, including the solid fuel holder.
(6) Gas-operated equipment with integral solid fuel holder(s) intended for flavoring, such as a radiant charbroiler(s), shall comply simultaneously with the requirements of ANSI/UL 300 that address the gas radiant charbroiler(s) and mesquite wood charbroiler(s).
(7) A fire suppression system nozzle(s) shall be installed to protect the solid fuel holder.
(8) The fire suppression system shall be designed and installed to protect the entire cooking operation.
(9) The Each solid fuel holder shall be limited to a size of 2000 150 cubic inches (2.5 L 0.0328 m³), with no dimension to exceed 20 inches (508 mm).
(10) A maximum of one solid fuel holder for each 100 000 Btu/hr (29 kW), or portion thereof, of burner capacity shall be permitted.
(11) Solid fuel shall be immersed in water for a continuous period of at least 24 hours immediately prior to being placed in the cooking equipment.
(12) The inspection frequency shall be the same as for solid fuel cooking operations in Table 514.3. [NFPA 96:14.3.4]

517.6 Air Movement for Solid-Fuel Cooking. Exhaust system requirements shall comply with Section 511.0 for hooded operation or shall be installed in accordance with the manufacturer’s installation instructions recommendations for unhooded applications. [NFPA 96:14.6.1]

517.7.6 Fuel Storage. Fuel All fuel storage areas shall be provided with a sprinkler system in accordance with meeting the requirements of NFPA 13 except where as permitted in accordance with the following:
(1) Where approved by acceptable to the Authority Having Jurisdiction, fuel storage areas shall be permitted to be protected with a fixed water pipe system with a hose capable of reaching all parts of the area.
(2) In lieu of the sprinkler system outlined in Section 517.7.6, a listed 2-A rated water spray fire extinguisher or a 1.6 gallon (6.1 L) wet chemical fire extinguisher listed for Class K fires with a maximum travel distance of not more than 20 feet (6096 mm) to the solid fuel piles shall be permitted to be used for a solid fuel pile, provided that the fuel pile does not exceed 5 cubic feet (0.14 m³) volume. [NFPA 96:14.9.2.8 – 9.2.8.2 14.9.2.8.2]

517.8.2 Additional Devices. Except for the spark arresters required in Section 517.1.6, there shall be no additional devices of any type in a any portion of the appliance, flue pipe, and chimney of a natural draft solid-fuel operation. [NFPA 96:14.9.4.4]

517.8.3 Prohibited. No solid-fuel cooking device of any type shall be permitted for deep-fat frying involving more than 1 quart (qt) (1 L) of liquid shortening, and nor shall any solid-fuel cooking device shall not be permitted within 3 feet (914 mm) of a any deep-fat frying unit. [NFPA 96:14.9.4.5]

518.0 Downdraft Appliances.
518.3 Fire-Extinguishing Equipment. For fire Fire-extinguishing equipment on a downdraft appliance ventilation system shall comply with systems, the following shall apply:
(1) Cooking surface, duct, and plenum protection shall be provided.
(2) Not less than At least one fusible link or heat detector shall be installed within an each exhaust duct opening in
accordance with the manufacturer’s listing.

3. A fusible link or heat detector shall be provided above the for each protected cooking appliance and located in the plenum area of that appliance or in accordance with the extinguishing system manufacturer’s listing.

4. A manual activation device shall be provided as part of the each appliance at a height acceptable to the approved by the Authority Having Jurisdiction.

5. Portable fire extinguishers shall be installed provided in accordance with Section 513.11. [NFPA 96:15.2]

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Note: EPA Test Method 202 does not meet the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Section Chapter 5 is being revised to the latest edition of NFPA 96-2018.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

507.0 General Requirements.

507.2 Exhaust System. Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system that complies with all the equipment and performance requirements of this chapter. [NFPA 96:4.1.1] All such equipment and its performance shall be maintained in accordance with the requirements of this chapter during all periods of operation of the cooking equipment. [NFPA 96:4.1.2] The following equipment shall be kept in working condition:

(1) Cooking equipment
(2) Hoods
(3) Ducts (if applicable)
(4) Fans
(5) Fire-extinguishing equipment
(6) Special effluent or energy control equipment [NFPA 96:4.1.3] Maintenance and repairs shall be performed on all components at intervals necessary to maintain good working conditions. [NFPA 96:4.1.3.1]

507.2.1 Airflow. All airflows shall be maintained. [NFPA 96:4.1.4]

507.2.2 Responsibility. The responsibility for inspection, testing, maintenance, and cleanliness of the ventilation control and fire protection of the commercial cooking operations, including cooking appliances, shall ultimately be that of the owner of the system, provided that this responsibility has not been transferred in written form to a management company, tenant, or other party. [NFPA 96:4.1.5]

507.2.3 Solid-fuel Cooking Equipment. All solid-fuel cooking equipment shall comply with the requirements of Section 517.0. [NFPA 96:4.1.6]

507.2.4 Multitenant Applications. Multitenant applications shall require the concerted cooperation of design, installation, operation, and maintenance responsibilities by tenants and by the building owner. [NFPA 96:4.1.7]

507.2.5 Interior Surfaces. All interior surfaces of the exhaust system shall be accessible for cleaning and inspection purposes. [NFPA 96:4.1.8]

507.2.6 Used in Other Applications. Cooking equipment used in fixed, mobile, or temporary concessions, such as trucks, buses, trailers, pavilions, tents, or any form of roofed enclosure, shall comply with this chapter. [NFPA 96:4.1.9]

507.4.4 Factory Built. Factory-built grease duct enclosures shall be protected with a through-penetration firestop system classified in accordance with ASTM E814 or UL 1479 having an “F” and a “T” rating equal to the fire resistance rating of the assembly being penetrated from the point at which the duct penetrates a ceiling, wall, or floor to the outlet terminal. [NFPA 96:4.3.3]

507.4.4.1 Listing. The factory-built grease duct protection system shall be listed in accordance with UL 2221. [NFPA 96:4.3.3.1]

507.4.4.2 Single Wall. Listed single wall factory-built grease ducts shall be permitted to be enclosed with field-applied grease duct enclosure material where the material and the assembly of duct and material are listed for that application and installed in accordance with the grease duct manufacturer’s listing and their installation instructions. [NFPA 96:4.3.3.2]

507.4.4.3 Installation. The factory-built grease duct protection system shall be installed in accordance with the manufacturer’s installation instructions and the listing requirements. [NFPA 96:4.3.3.3]
508.0 Type I Hoods.

508.2 Listed Type I Hood Assemblies. Listed hood assemblies shall be installed in accordance with the terms of their listing and the manufacturer’s instructions. Listed hood assemblies shall be tested in accordance with UL 710 or equivalent. [NFPA 96:5.4.1, 5.4.2]

508.2.1 Listed Ultraviolet Hoods. Listed ultraviolet hoods shall be installed and maintained in accordance with the terms of their listing and the manufacturer’s instructions. Duct systems connected to ultraviolet hoods shall comply with Section 510.0. Ultraviolet hoods shall be tested and listed in accordance with UL 710 and UL 710C. [NFPA 96:5.5-5.5.2]

507.4.4.3 Listed Ventilated Ceiling Technology. Listed ventilated ceiling technology shall be installed and maintained in accordance with the terms of its listing and the manufacturer’s instructions. [NFPA 96:5.6]

(renumber remaining sections)

508.3 Construction of Type I Hoods. The hood or that portion of a primary collection means designed for collecting cooking vapors and residues shall be constructed of and be supported by steel not less than 0.048 of an inch (1.219 mm) (No. 18 MSG), in thickness, stainless steel not less than 0.036 of an inch (0.914 mm) (No. 20 MSG) in thickness, or other approved material of equivalent strength and fire and corrosion resistance. [NFPA 96:5.1.1]

Exception: Listed exhaust hoods.

509.0 Grease Removal Devices in Hoods.

509.1 Grease Removal Devices. Listed grease filters or other listed grease removal devices intended for use with commercial cooking operations shall be provided. Listed grease filters and grease removal devices that are removable but not an integral component of a specific listed exhaust hood shall be listed in accordance with ANSI/UL 1046 and shall be designated on the filter. [NFPA 96:6.1.1, 6.1.2]

509.2.1 Vertical Distance. Where grease removal devices are used in conjunction with solid fuel or solid fuel-type broilers, including gas or electrically heated charbroilers, a minimum vertical distance of 4 feet (1219 mm) shall be maintained between the lower edge of the grease removal device and the cooking surface. [NFPA 96:6.2.1.2]

Exceptions:
(1) For cooking equipment without exposed flame and where flue gases bypass grease removal devices, the minimum vertical distance shall be permitted to be reduced to not less than 6 inches (152 mm). [NFPA 96:6.2.1.3]
(2) Where a grease removal device is listed for separation distances less than those required in Section 509.2 and Section 509.2.1, the listing requirements shall be permitted. [NFPA 96:6.2.1.4]
(3) Grease removal devices supplied as part of listed hood assemblies shall be installed in accordance with the terms of the listing and the manufacturer’s instructions. [NFPA 96:6.2.1.5]

509.2.3.1 Arrangement. Grease filters shall be arranged so that all exhaust air passes through the grease filters. [NFPA 96:6.2.3.4]

509.2.4.1 Size and Pitch. Grease drip trays shall be kept to the minimum size needed to collect grease. Grease drip trays shall be pitched to drain into an enclosed metal container having a capacity not exceeding 1 gallon (4 L). [NFPA 96:6.2.4.2, 6.2.4.3]

509.2.5 Grease Filter Orientation. Grease filters that require a specific orientation to drain grease shall be clearly so designated on the face of the filter as to be visible with the filter installed, or the hood or filter shall be constructed so that filters cannot be installed in the wrong orientation. [NFPA 96:6.2.5]

510.0 Exhaust Duct Systems.

510.1.2 Interconnection. Duct systems shall not be interconnected with any other building ventilation or exhaust system. [NFPA 96:7.1.3]

510.1.3 Duct Installation. All ducts shall be installed with a minimum 2 percent slope on horizontal runs up to 75 feet (22 860 mm) and a minimum 8 percent slope on horizontal runs greater than 75 feet (22 860 mm). Factory-built grease ducts shall be permitted to be installed at a lesser slope in accordance with the listing and the manufacturer’s instructions. All horizontal ducts shall be provided with access in accordance with Section 510.3.3.

Drains shall be provided at low points in horizontal ducts. Where provided, drains shall be continuously welded to the exhaust duct in accordance with the terms of the listing and the manufacturer’s installation manual. All ducts shall be installed without forming dips or traps. In manifold (common duct) systems, the lowest end of the main duct shall be connected flush on the bottom with the branch duct. [NFPA 96:7.1.4 – 7.1.4.5]

510.1.5 Sign. A sign stating the following shall be placed on all access panels:
ACCESS PANEL – DO NOT OBSTRUCT [NFPA 96:7.1.6]

510.1.7 Type I Exhaust Duct Systems. Listed grease ducts shall be installed in accordance with the terms of their listings and manufacturer’s instructions. [NFPA 96:7.1.7]

510.3.4.2 Safe Access and Work Platform. If not easily accessible from the floor or a 10 foot (3048 mm) stepladder, openings
on vertical grease ducts shall be provided with safe access and a work platform. [NFPA 96:7.4.2.3]

510.3.6 Access Panels. Access panels shall be of the same material and thickness as the duct. Access panels shall have a gasket or sealant that is rated for 1500°F (816°C) and shall be greasertight. Fasteners, such as bolts, weld studs, latches, or wing nuts, used to secure the access panels shall be carbon steel or stainless steel and shall not penetrate duct walls. [NFPA 96:7.4.3.1-7.4.3.3]

510.3.6.1 Listed Grease Ducts. Listed grease duct access door assemblies (access panels) shall be installed in accordance with the terms of the listing and the manufacturer’s instructions. [NFPA 96:7.4.3.4]

510.4 Listed Grease Ducts. Listed grease ducts shall be installed in accordance with the terms of the listing and the manufacturer’s instructions. [NFPA 96:7.1.7]

510.5.5 Telescoping and Bell-Type Connections. For telescoping and bell-type connections, the inside duct section shall always be uphill of the outside duct section. [NFPA 96:7.5.5.3] The overlap shall not exceed 2 inches (51 mm) as shown in Figure 510.5.3.2(1).

510.7 Interior Installations. In all buildings more than one story in height and in one-story buildings where the roof-ceiling assembly is required to have a fire resistance rating, the ducts shall be enclosed in a continuous enclosure extending from the lowest fire-rated ceiling or floor above the hood, through any concealed spaces, to or through the roof, to maintain the integrity of the fire separations required by the applicable building code provisions. The enclosure shall be sealed around the duct at the point of penetration of the first fire-rated barrier after the hood, to maintain the fire resistance rating of the enclosure. The enclosure shall be vented to the exterior of the building through weather-protected openings. [NFPA 96:7.7.1.2 – 7.7.1.4]

Exception: The continuous enclosure provisions shall not be required where a field-applied grease duct enclosure or a factory-built grease duct enclosure (see Section 507.4.4 through Section 507.4.6) is protected with a listed duct-through-penetration protection system equivalent to the fire resistance rating of the assembly being penetrated and where the materials are installed in accordance with the conditions of the listings and the manufacturer’s instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.1.5]

510.7.3 Clearance. Clearance from the duct or the exhaust fan to the interior surface of enclosures of combustible construction shall be not less than 18 inches (457 mm). Clearance from the duct to the interior surface of enclosures of noncombustible or limited-combustible construction shall be not less than 6 inches (152 mm). Provisions for reducing clearances as described in Section 507.4 through Section 507.4.3.3 shall not be applicable to enclosures. [NFPA 96:7.7.2.2.1 – 7.7.2.2.3]

Exception: Clearance from the outer surfaces of field-applied grease duct enclosures and factory-built grease duct enclosures to the interior surfaces of construction installed around them shall be permitted to be reduced where the field-applied grease duct enclosure materials and factory-built grease duct enclosures are installed in accordance with the conditions of the listing and the manufacturer’s instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.2.2.4]

510.7.4 Mechanical and Structural Integrity. Field-applied grease duct enclosures and factory-built grease duct enclosures shall provide mechanical and structural integrity, resiliency, and stability when subjected to expected building environmental conditions, duct movement under general operating conditions, and duct movement as a result of interior and exterior fire conditions. [NFPA 96:7.7.2.2.5]

510.7.5 Protection from Physical Damage. Measures shall be taken to prevent physical damage to any covering or enclosure material. Any damage to the covering or enclosure shall be repaired, and the covering or enclosure shall be restored to meet its intended listing and fire resistance rating and to be acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.1, 7.7.3.2]

510.7.5.2 Inspection. In the event of a fire within a kitchen exhaust system, the duct, the enclosure, and the covering directly applied to the duct shall be inspected by qualified personnel to determine whether the duct, the enclosure, and the covering directly applied to the duct are structurally sound, capable of maintaining their fire protection functions, suitable for continued operation, and acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.3]

510.7.7 Fire Doors. Where openings in the enclosure walls are provided, they shall be protected by listed fire doors of proper rating. Fire doors shall be installed in accordance with NFPA 80. Openings on other listed materials or products shall be clearly identified and labeled according to the terms of the listing and the manufacturer’s instructions and shall be acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.4.1 – 7.7.4.3] The fire door shall be readily accessible, aligned, and of sufficient size to allow access to the rated access panels on the ductwork. [NFPA 96:7.7.4.4]

510.7.8 Ducts with Enclosure(s). Each duct system shall constitute an individual system serving only exhaust hoods in one fire zone on one floor. Multiple ducts shall not be permitted in a single enclosure unless acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.5 – 7.7.5.2]

510.9 Rooftop Terminations. Rooftop terminations shall be arranged with or provided with the following:

1. A minimum of 10 feet (3048 mm) of horizontal clearance from the outlet to adjacent buildings, property lines, and air intakes.
2. A minimum of 5 feet (1524 mm) of horizontal clearance from the outlet (fan housing) to any combustible structure.
3. A vertical separation of 3 feet (914 mm) above any air intakes within 10 feet (3048 mm) of the exhaust outlet.
4. The ability to drain grease out of traps or low points formed in the fan or duct near the termination of the system into a...
collection container that is noncombustible, closed, rainproof, and structurally sound for the service to which it is applied and that will not sustain combustion.

(5) A grease collection device that is applied to exhaust systems that does not inhibit the performance of any fan.

(6) Listed grease collection systems that meet the requirements of Section 510.9.1(4) and Section 510.9.1(5).

(7) A listed grease duct complying with Section 507.4.7 or ductwork complying with Section 507.4.8.

(8) A hinged upblast fan supplied with flexible weatherproof electrical cable and service hold-open retainer to permit inspection and cleaning that is listed for commercial cooking equipment with the following conditions:

(a) Where the fan attaches to the ductwork, the ductwork is a minimum of 18 inches (457 mm) away from any roof surface, as shown in Figure 510.9.1.

(b) The fan discharges a minimum of 40 inches (1016 mm) away from any roof surface, as shown in Figure 510.9.1.

(9) Other approved fan, provided it meets all of the following criteria:

(a) The fan meets the requirements of Section 510.9.1(3) and Section 511.1.3.

(b) Its discharge or its extended duct discharge meets with the requirements of Section 510.9.1(2). (See Section 511.1.3)

(c) Exhaust fan discharge is directed up and away from the roof surface. [NFPA 96:7.8.2.1]

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

**Notes:**

1. Fresh air intake (FAI) applies to an air intake, including an operable door or window.

2. Example:

(a) FAIs 1 and 5 are on the same plane of exhaust or lower: 10 feet (3048 mm) min. between closest edges.

(b) FAIs 2, 3, and 4 are above plane of exhaust fan:

10 feet + 0.25 feet (3048 mm + 76mm) per degree between closest edges.

**FIGURE 510.9.2**

EXHAUST TERMINATION DISTANCE FROM FRESH AIR INTAKE (FAI) OR OPERABLE DOOR OR WINDOW

[NFPA 96: FIGURE 7.8.3]

511.0 Air Movement.

511.1 Exhaust Fans for Commercial Cooking Operations. (remaining text unchanged)

511.1.2.1 Accessibility. Where the design or positioning of the fan allows grease to be trapped, a drain directed to a readily accessible and visible grease receptacle not exceeding 1 gallon (4 L), shall be provided. In-line exhaust fans shall be located in easily accessible areas of adequate size to allow for service or removal. Where the duct system connected to the fan is in an enclosure, the space or room in which the exhaust fan is located shall have the same fire resistance rating as the enclosure. [NFPA 96:8.1.3.4 – 8.1.3.6]

511.2.3 Exhaust Fan Operation. A hood exhaust fan(s) shall continue to operate after the extinguishing system has been activated unless fan shutdown is required by a listed component of the ventilation system or by the design of the extinguishing system. The hood exhaust fan shall start upon activation of the extinguishing system if the exhaust fan and all cooking equipment served by the fan have been shut down, unless fan shutdown is required by a listed component of the ventilation system or by the listing of the extinguishing system. The exhaust fan shall be provided with a means so that the fan is activated when any heat-producing cooking appliance under the hood is turned on. [NFPA 96:8.2.3.1-8.2.3.3]

512.0 Auxiliary Equipment.

512.2 Electrical Equipment. Wiring systems of any type shall not be installed in ducts. [NFPA 96:9.2.1]
512.2.1 Device Installation in Ducts. Motors, lights, and other electrical devices shall be permitted to be installed in ducts or hoods or to be located in the path of travel of exhaust products only where specifically listed for such use. [NFPA 96:9.2.2]

512.2.2 Lighting Units. Lighting units on hoods shall not be located in concealed spaces except as permitted by Section 512.2.3 and Section 512.2.4. [NFPA 96:9.2.3.2]

512.3 Other Equipment. Fume incinerators, thermal recovery units, air pollution control devices, or other devices shall be permitted to be installed in ducts or hoods or to be located in the path of travel of exhaust products where specifically listed for such use. [NFPA 96:9.3.1]

512.3.1 Access Required. Equipment shall have space provided to all access panels or doors for the safe removal and servicing of control devices, such as filters, electrostatic precipitator cells, and odor control media beds, and for cleaning of the equipment housing. [NFPA 96:9.3.1.3]

512.3.2 Downgrading. Downgrading other parts of the exhaust system due to the installation of approved devices, whether listed or not, shall not be allowed. [NFPA 96:9.3.2]

512.3.3 Fire-Extinguishing System. Any equipment installed in the path of exhaust products that provides secondary filtration or air pollution control shall be provided with an approved automatic fire-extinguishing system, installed in accordance with the fire-extinguishing system manufacturer’s instructions. [NFPA 96:9.3.3]

512.3.3.1 Protection. The fire-extinguishing system required by Section 512.3.3 shall provide protection for the component sections of the equipment, and ductwork downstream of the equipment. [NFPA 96:9.3.3.1]

512.3.3.2 Filter Media. Filter media used in secondary filtration or air pollution control units and not complying with Section 509.2.3 shall have fire protection that is adequate for the filter media being used in accordance with the fire-extinguishing system manufacturer’s instructions. [NFPA 96:9.3.3.2]

512.3.4 Source of Ignition. If the equipment provides a source of ignition, it shall be provided with detection to operate the fire-extinguishing system protecting the equipment. [NFPA 96:9.3.4]

512.3.5 Air Recirculation. Where a cooking exhaust system employs an air pollution control device that recirculates air into the building, the requirements of Section 516.0 shall apply. [NFPA 96:9.3.5]

512.3.6 Carbon Monoxide Required. If the heat source is non-electric and open flames are used, a carbon monoxide detector shall be installed in both the kitchen and dining areas. [NFPA 96:9.3.7]

513.0 Fire-Extinguishing Equipment.

513.1 General. (remaining text unchanged)

513.1.1 Devices in Exhaust Ducts. Fume incinerators, thermal recovery units, air pollution control devices, or other devices installed in the exhaust duct, shall be protected by an automatic fire-extinguishing system. [NFPA 96:10.1.3]

513.2.5 Baffle Hoods with Water Wash. Areas requiring protection in accordance with Section 513.1 shall be permitted to be protected by a water-wash system that is listed as a fire-extinguishing system in compliance with UL 300 or other equivalent standards and installed in accordance with the requirements of its listing. [NFPA 96:10.2.8.1]

513.2.5.1 Listed for the Purpose. Each such area not provided with a listed water-wash fire-extinguishing system shall be provided with a fire-extinguishing system listed for the purpose. [NFPA 96:10.2.8.2]

513.2.5.2 Control Valve. The water supply for water-wash fire-extinguishing systems shall be controlled by a listed indicating valve. [NFPA 96:10.2.8.4]

513.2.5.3 Activation. Where a separate fire-extinguishing system is used for protection of cooking equipment only, a water-wash fire-extinguishing system listed for protection of the grease removal device(s), hood exhaust plenum(s), exhaust duct(s), or combination thereof shall be provided with instructions and appropriate means for electrical interface for simultaneous activation. [NFPA 96:10.2.8.5]

513.2.5.4 Water-Wash System. A water-wash system approved to be used for protection of the grease removal device(s), hood exhaust plenum(s), exhaust duct(s), or combination thereof shall include instructions and appropriate electrical interface for simultaneous activation of the water-wash system from an automatic fire-extinguishing system, where the automatic fire-extinguishing system is used for cooking equipment protection only. [NFPA 96:10.2.8.6]

513.2.5.5 Exception. Where the automatic fire-extinguishing system in accordance with NFPA 17A provides protection for the hood and duct in a fixed baffle hood containing a water-wash system, the water-wash system shall be made inoperable or delayed for a minimum of 60 seconds upon operation of the automatic fire-extinguishing system. [NFPA 96:10.2.8.7]

513.2.5.6 Water Supply. The water required for listed automatic fire-extinguishing systems shall be permitted to be supplied from the domestic water supply where the minimum water pressure and flow are provided in accordance with the terms of the listing. The
water supply shall be controlled by a supervised water supply control valve. Where the water supply is from a dedicated fire protection water supply in a building with one or more fire sprinkler systems, separate indicating control valves and drains shall be provided and arranged so that the hood system and sprinkler systems can be controlled individually. [NFPA 96:10.2.9.1, 10.2.9.2]

513.2.6 Water Valve Supervision. Valves controlling the water supply to listed water-wash fire-extinguishing systems, automatic fire-extinguishing systems, or both shall be listed indicating type of valve and shall be supervised open by one of the following methods:

1. Central station, proprietary, or remote station alarm service.
2. Local alarm service that will cause the sounding of an audible signal at a constantly attended point.
3. Locking valves open.
4. Sealing of valves and approved weekly recorded inspection. [NFPA 96:10.2.10]

513.3 Simultaneous Operation. Fixed pipe extinguishing systems in a single hazard area shall be arranged for simultaneous automatic operation upon actuation of any one of the systems. [NFPA 96:10.3.1]

513.3.1 Hoods. Hoods installed end to end, back to back, or both, or sharing a common ductwork, not exceeding 75 feet (22 860 mm) in distance from the farthest hood, and having a grease producing appliance(s) located under one or more of the hoods, shall be considered a single hazard area requiring simultaneous automatic fire protection in all hoods and ducts. [NFPA 96:10.3.1.1]

513.3.1.1 Common Ductwork. In hoods that are installed end to end, back to back, or both, and that share a common ductwork, the ductwork beyond 75 feet (22 860 mm) from the farthest hood shall be protected by an independent fire-extinguishing system with its own detection system or by a fire-extinguishing system that activates simultaneously with the fire-extinguishing system(s) protecting the hoods. [NFPA 96:10.3.1.1.1]

513.3.2 Independent Systems. Hoods installed end to end, back to back, or both that do not share a common exhaust duct and are separated by a wall(s) or other means to ensure that grease-laden vapors exhausted under one hood cannot propagate to the other hoods, the hoods' fire-extinguishing system(s) shall be independent and shall not be required to simultaneously discharge. [NFPA 96:10.3.1.2]

513.3.3 Exempt Equipment. Fume incinerators, thermal recovery units, air pollution control devices, or other devices installed in the exhaust duct shall not be required to comply with Section 513.3.1. [NFPA 96:10.3.1.3]

(renumber remaining sections)

513.3.1 Automatic Sprinkler System. Simultaneous operation shall not be required where the one fixed pipe extinguishing system is an automatic sprinkler system. Where an automatic sprinkler system is used in conjunction with a water-based fire-extinguishing system served by the same water supply, hydraulic calculations shall consider both systems operating simultaneously. [NFPA 96:10.3.2, 10.3.2.1]

513.3.2 Dry or Wet Chemical Systems. Simultaneous operation shall be required where a dry or wet chemical system is used to protect common exhaust ductwork by one of the methods specified in NFPA 17 or NFPA 17A. [NFPA 96:10.3.3]

513.4.1 Steam. Steam supplied from an external source shall not be required to automatically shut off. [NFPA 96:10.4.2]

513.5 Manual Activation. All systems shall have both automatic and manual methods of actuation. At least one manual actuation device shall be located in a means of egress or at a location acceptable to the Authority Having Jurisdiction.

The manual actuation device shall clearly identify the hazard protected. An automatic sprinkler system shall not require a method of manual actuation. [NFPA 96:10.5.1 – 10.5.3]

513.8 Special Design and Application. Hoods containing automatic fire-extinguishing systems are protected areas; therefore, these hoods shall not be considered obstructions to overhead sprinkler systems and shall not require floor additional sprinkler coverage underneath. [NFPA 96:10.7.1]

513.10 Installation Requirements. Installation of systems shall be performed only by persons properly trained and qualified to install the specific system being provided. The installer shall provide certification to the Authority Having Jurisdiction that the installation is in agreement with the terms of the listing and the manufacturer’s instructions and/or approved design. [NFPA 96:10.8.2.1, 10.8.2.2]

513.11 Portable Fire Extinguishers. Portable fire extinguishers shall be selected and installed in kitchen cooking areas in accordance with NFPA 10 and shall be specifically listed for such use. Class K fire extinguishers shall be provided for cooking appliance hazards that involve combustible cooking media (vegetable oils and animal oils and fats). [NFPA 96:10.9.1, 10.9.2]

513.11.1 Other Fire Extinguishers. Portable fire extinguishers shall be provided for other hazards in kitchen areas and shall be selected and installed in accordance with NFPA 10. [NFPA 96:10.9.3]

513.11.2 Carbon Dioxide-Type. Carbon dioxide-type extinguishers shall not be permitted. [NFPA 96:10.9.4]

514.0 Procedures for the Use, Inspection, Testing, and Maintenance of Equipment.

514.1 Operating Procedures. Exhaust systems shall be operated whenever cooking equipment is turned on. [NFPA 96:11.1.1]

514.1.6 Secondary Control Equipment. Secondary filtration and pollution control equipment shall be operated in accordance
with the terms of its listing and the manufacturer’s recommendations. [NFPA 96:11.1.7]

514.1.7 Inspection Frequency. Inspection and maintenance of “other equipment” as allowed in Section 512.3 shall be conducted by properly trained and qualified persons at a frequency determined by the manufacturer’s instructions or the equipment listing. [NFPA 96:11.1.8]

514.2 Inspection, Testing, and Maintenance. Maintenance of the fire-extinguishing systems and listed exhaust hoods containing a constant or fire-activated water system that is listed to extinguish a fire in the grease removal devices, hood exhaust plenums, and exhaust ducts shall be made by properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction at least every 6 months. [NFPA 96:11.1.8]

514.2.1 Requirements. All actuation and control components, including remote manual pull stations, mechanical and electrical devices, detectors, and actuators shall be tested for proper operation during the inspection in accordance with the manufacturer’s procedures. The specific inspection and maintenance requirements of the extinguishing system standards as well as the applicable installation and maintenance manuals for the listed system and service bulletins shall be followed. [NFPA 96:11.2.2, 11.2.3]

514.2.2 Fusible Links and Sprinklers. Fusible links of the metal alloy type and automatic sprinklers of the metal alloy type shall be replaced at least semiannually. [NFPA 96:11.2.4]

514.2.4 Temperature-Sensing Elements. Fixed temperature-sensing elements other than the fusible metal alloy type shall be permitted to remain continuously in service, provided they are inspected and cleaned, or replaced if necessary in accordance with the manufacturer’s instructions, every 12 months or more frequently to ensure proper operation of the system. [NFPA 96:11.2.7]

514.3 Inspection for Grease Buildup. The entire exhaust system shall be inspected for grease buildup by a properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction and in accordance with Table 514.3. [NFPA 96:11.4]

### TABLE 514.3
**SCHEDULE OF INSPECTION FOR GREASE BUILDUP**

<table>
<thead>
<tr>
<th>TYPE OR VOLUME OF COOKING</th>
<th>INSPECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems serving solid fuel cooking operations.</td>
<td>Monthly</td>
</tr>
<tr>
<td>1Systems serving high-volume cooking operations.</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Systems serving moderate-volume cooking operations.</td>
<td>Semiannually</td>
</tr>
<tr>
<td>2Systems serving low-volume cooking operations.</td>
<td>Annually</td>
</tr>
</tbody>
</table>

Notes:
1. High-volume cooking operations include 24-hour cooking, charbroiling, and wok cooking.
2. Low-volume cooking operations include churches, day camps, seasonal businesses, and senior centers.

514.4 Cleaning of Exhaust Systems. If, upon inspection, the exhaust system is found to be contaminated with deposits from grease-laden vapors, the contaminated portions of the exhaust system shall be cleaned by a properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.6.1]

514.4.1 Measurement System. A measurement system of deposition shall be established to trigger a need to clean when the exhaust system is inspected at the frequencies in Table 514.3. [NFPA 96:11.6.1.1]

514.4.1.1 Combustible Contaminants. Hoods, grease removal devices, fans, ducts, and other appurtenances shall be cleaned to remove combustible contaminants to a minimum of 0.002 of an inch (50 µm). [NFPA 96:11.6.1.1.1]

514.4.1.2 Gauge Comb. A grease depth gauge comb as shown in Figure 514.4.1.2 shall be placed upon the surface to measure grease depth. [NFPA 96:11.6.1.1.2]
514.4.1.3 **Cleaning Method.** Where a measured depth of 0.078 of an inch (2000 µm) is observed, the surfaces shall be cleaned in accordance with Section 514.4. [NFPA 96:11.6.1.1.3]

514.4.1.4 **Combustible Contaminants.** Where a measured depth of 0.125 of an inch (3175 µm) is observed in a fan housing, the surfaces shall be cleaned in accordance with Section 514.4. [NFPA 96:11.6.1.1.4]

(renumber remaining sections)

514.4.4 **Inoperable.** Fire-extinguishing systems shall be permitted to be rendered inoperable during the cleaning process where serviced by properly trained and qualified persons. [NFPA 96:11.6.5]

514.4.8 **Access Panels and Cover Plates.** When cleaning procedures are completed, all access panels (doors) and cover plates shall be restored to their normal operational condition. [NFPA 96:11.6.9]

514.4.9 **Date of Inspection.** When an access panel is removed, a service company label or tag preprinted with the name of the company and giving the date of inspection or cleaning shall be affixed near the affected access panels. [NFPA 96:11.6.10]

514.4.11 **Operable State.** When cleaning procedures are completed, all electrical switches and system components shall be returned to an operable state. [NFPA 96:11.6.12]

514.4.12 **Certification of Service.** When an exhaust system is inspected or cleaned, a certificate showing the name of the servicing company, the name of the person performing the work, and the date of inspection or cleaning shall be maintained on the premises. [NFPA 96:11.6.13]

514.4.15 **Metal Containers.** Metal containers used to collect grease drippings shall be inspected or emptied at least weekly. [NFPA 96:11.6.16]

515.0 **Minimum Safety Requirements for Cooking Equipment.**

515.1 **Cooking Equipment.** (remaining text unchanged)

515.1.1 **Installation.** All listed appliances shall be installed in accordance with the terms of their listings and the manufacturer’s instructions. Solid fuel used for flavoring within a gas-operated appliance shall be in a solid fuel holder (smoker box) that is listed with the equipment. [NFPA 96:12.1.2.1, 12.1.2.1.1]

515.1.1.2 **Prior Location.** The fire-extinguishing system shall not require re-evaluation where the cooking appliances are moved for the purposes of maintenance and cleaning, provided the appliances are returned to approved design location prior to cooking operations, and any disconnected fire-extinguishing system nozzles attached to the appliances are reconnected in accordance with the manufacturer’s listed design manual. [NFPA 96:12.1.2.3]

516.0 **Recirculating Systems.**

516.1 **General Requirements.** Recirculating systems containing or for use with appliances used in processes producing smoke or grease-laden vapors shall be equipped with components complying with the following:

1. The clearance requirements of Section 507.4.
2. A hood complying with the requirements of Section 508.0.
3. Grease removal devices complying with Section 509.0.
4. The air movement requirements of Section 511.2.1 and Section 511.2.2.
5. Auxiliary equipment (such as particulate and odor removal devices) complying with Section 512.0.
6. Fire-extinguishing equipment complying with the requirements of Section 513.0.

**Exception:** Fire-extinguishing equipment in accordance with Section 513.1 and Section 513.5.

1. The use and maintenance requirements of Section 514.0.
2. The minimum safety requirements of Section 515.0.
516.2.9 Listing Evaluation. Listing evaluation shall include the following:
(1) Capture and containment of vapors at published and labeled airflows.
(2) Grease discharge at the exhaust outlet of the system not to exceed an average of 2.9 E-09 (oz/in$^3$) (5.0 E-06 kg/m$^3$) of exhausted air sampled from that equipment at maximum amount of product that is capable of being processed over a continuous 8 hour test per EPA Test Method 202, with the system operating at its minimum listed airflow.
(3) Listing and labeling of clearance to combustibles from all sides, top, and bottom.
(4) Electrical connection in the field in accordance with NFPA 70.
(5) Interlocks on all removable components that lie in the path of airflow within the unit to ensure that they are in place during operation of the cooking appliance. [NFPA 96:13.2.12]

516.3.4 Airflow Switch or Transducer. An airflow switch or transducer shall be provided after the last filter component to ensure that a minimum airflow is maintained. The airflow switch or transducer shall open the interlock circuit when the airflow falls 25 percent below the system’s normal operating flow or 10 percent below its listed minimum rating, whichever is lower. The airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:13.3.5.1 – 13.3.5.3]

516.5 Additional Fire Safety Requirements. In addition to the appliance nozzle(s), a recirculating system shall be listed with the appropriate fire protection for grease filters, grease filtration, odor filtration units, and ductwork, where applicable. [NFPA 96:13.5.1]

516.6.2 Cleaning Schedule. All ESPs shall be cleaned a minimum of once per week and according to the manufacturer’s cleaning instructions. [NFPA 96:13.6.3]

516.6.3 Hood Plenum and Blower Section Cleaning Schedule. The entire hood plenum and the blower section shall be cleaned a minimum of once every 3 months. [NFPA 96:13.6.4]

516.6.4 Inspection of Safety Interlocks. Inspection and testing of the total operation and all safety interlocks in accordance with the manufacturer’s instructions shall be performed by qualified service personnel a minimum of once every 6 months or more frequently if required. [NFPA 96:13.6.5]

517.0 Solid-Fuel Cooking Operations.

517.3 Hoods for Solid-Fuel Cooking.
(remaining text unchanged)

517.3.1 Separation. (remaining text unchanged)

517.3.1.1 Equipment with Solid Fuel for Flavoring. Gas-operated equipment utilizing solid fuel for flavoring that meets all the following conditions shall not be required to have a separate exhaust system:
(1) The solid fuel holder (smoker box) shall be listed with the gas-operated equipment.
(2) The solid fuel holder shall be located underneath the gas burners.
(3) Spark arresters conforming with Section 517.1.6 shall be provided.
(4) The maximum quantity of solid fuel consumed shall not exceed 1 pound (0.45 kg) per hour per 100 000 Btu/hr (29 kW) of gas burner capacity.
(5) The gas-operated equipment shall be protected by a fire suppression system listed for the equipment, including the solid fuel holder.
(6) Gas-operated equipment with integral solid fuel holder(s) intended for flavoring, such as radiant charbroiler(s), shall comply simultaneously with the requirements of ANSI/UL 300 that address the gas radiant charbroiler(s) and mesquite wood charbroiler(s).
(7) A fire suppression system nozzle(s) shall be installed to protect the solid fuel holder.
(8) The fire suppression system shall be designed and installed to protect the entire cooking operation.
(9) Each solid fuel holder shall be limited to a size of 150 cubic inches (2.5 L), with no dimension to exceed 20 inches (508 mm).
(10) A maximum of one solid fuel holder for each 100 000 Btu/hr (29 kW), or portion thereof, of burner capacity shall be permitted.
(11) Solid fuel shall be immersed in water for a continuous period of at least 24 hours immediately prior to being placed in the cooking equipment.
(12) The inspection frequency shall be the same as for solid fuel cooking operations in Table 514.3. [NFPA 96:14.3.4]

517.6 Air Movement for Solid-Fuel Cooking. Exhaust system requirements shall comply with Section 511.0 for hooded operation or shall be installed in accordance with the manufacturer’s recommendations for unhooded applications. [NFPA 96:14.6.1]

517.7.6 Fuel Storage. All fuel storage areas shall be provided with a sprinkler system meeting the requirements of NFPA 13 except as permitted in accordance with the following:
(1) Where acceptable to the Authority Having Jurisdiction, fuel storage areas shall be permitted to be protected with a fixed water pipe system with a hose capable of reaching all parts of the area.
(2) In lieu of the sprinkler system outlined in Section 517.7.6, a listed 2-A rated water spray fire extinguisher or a 1.6 gallon (6.1 L) wet chemical fire extinguisher listed for Class K fires with a maximum travel distance of 20 feet (6096 mm) to the solid fuel piles shall be permitted to be used for a solid fuel pile, provided that the fuel pile does not exceed 5 cubic feet (0.14 m$^3$) volume. [NFPA 96:14.9.2.8 – 14.9.2.8.2]
517.8.2 Additional Devices. Except for the spark arresters required in Section 517.1.6, there shall be no additional devices of any type in any portion of the appliance, flue pipe, and chimney of a natural draft solid fuel operation. [NFPA 96:14.9.4.4]

517.8.3 Prohibited. No solid fuel cooking device of any type shall be permitted for deep fat frying involving more than 1 quart (qt) (1 L) of liquid shortening, nor shall any solid fuel cooking device be permitted within 3 feet (914 mm) of any deep fat frying unit. [NFPA 96:14.9.4.5]

518.0 Downdraft Appliances.

518.3 Fire-Extinguishing Equipment. For fire-extinguishing equipment on downdraft appliance ventilation systems, the following shall apply:
1. Cooking surface, duct, and plenum protection shall be provided.
2. At least one fusible link or heat detector shall be installed within each exhaust duct opening in accordance with the manufacturer’s listing.
3. A fusible link or heat detector shall be provided for each protected cooking appliance located in the plenum area of that appliance or in accordance with the extinguishing system manufacturer’s listing.
4. A manual activation device shall be provided as part of each appliance at a height acceptable to the Authority Having Jurisdiction.
5. Portable fire extinguishers shall be provided in accordance with Section 513.11. [NFPA 96:15.2]

### TABLE 1701.1

<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>EPA Test Method 202-2016</td>
<td>Best Practices Handbook</td>
<td>Commercial Kitchens</td>
<td>516.2.9</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**COMMITTEE STATEMENT:**
The proposed text in Section 510.5.5 is being revised to correlate with Item # 39. Furthermore, the reference to EPA Test Method 202 is being removed from Section 516.2.9 as it is not an enforceable document.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**

<table>
<thead>
<tr>
<th>AFFIRMATIVE</th>
<th>NOT RETURNED</th>
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</thead>
<tbody>
<tr>
<td>25</td>
<td>1 HOWARD</td>
</tr>
</tbody>
</table>

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 3-4 of the Regulations Governing Committee Projects.

Actions taken on UMC Item # 044, Section 509.1 (Grease Removal Devices) and Section 517.3.1.1 (Equipment with Solid Fuel for Flavoring) resulted in conflicting language between UPC Item # 157, Section 1211.3 (Arc-Resistant Jacketed CSST). In order to correlate the language, the Technical Correlating Committee proposed the following modifications to the UMC:

509.1 Grease Removal Devices. Listed grease filters or other listed grease removal devices intended for use with commercial cooking operations shall be provided. Listed grease filters and grease removal devices that are removable but not an integral component of a specific listed exhaust hood shall be listed in accordance with ANSI/UL 1046 and shall be designated on the filter. [NFPA 96:6.1.1, 6.1.2]

517.3.1.1 Equipment with Solid Fuel for Flavoring. Gas-operated equipment utilizing solid fuel for flavoring that meets all the following conditions shall not be required to have a separate exhaust system:
1. The solid fuel holder (smoker box) shall be listed with the gas-operated equipment.
2. The solid fuel holder shall be located underneath the gas burners.
3. Spark arresters conforming with Section 517.1.6 shall be provided.
4. The maximum quantity of solid fuel consumed shall not exceed 1 pound (0.45 kg) per hour per 100 000 Btu/hr (29 kW) of gas burner capacity.
5. The gas-operated equipment shall be protected by a fire suppression system listed for the equipment, including the solid fuel holder.
6. Gas-operated equipment with integral solid fuel holder(s) intended for flavoring, such as radiant charbroiler(s), shall comply simultaneously with the requirements of ANSI/UL 300 that address the gas radiant charbroiler(s) and mesquite wood charbroiler(s).
7. A fire suppression system nozzle(s) shall be installed to protect the solid fuel holder.
8. The fire suppression system shall be designed and installed to protect the entire cooking operation.
9. Each solid fuel holder shall be limited to a size of 150 cubic inches (2.5 L), with no dimension to exceed 20 inches (508 mm).
10. A maximum of one solid fuel holder for each 100 000 Btu/hr (29 kW), or portion thereof, of burner capacity shall be permitted.
(11) Solid fuel shall be immersed in water for a continuous period of at least 24 hours immediately prior to being placed in the cooking equipment.

(12) The inspection frequency shall be the same as for solid fuel cooking operations in Table 514.3. [NFPA 96:14.3.4]

**TCC ACTION:** ACCEPT AS SUBMITTED

**TCC STATEMENT:** The language in UMC Item # 044, Section 509.1 (Grease Removal Devices) and Section 517.3.1.1 (Equipment with Solid Fuel for Flavoring) are being revised to correlate with the language approved by the UPC TC Item # 157, Section 1211.3 (Arc-Resistant Jacketed CSST) with regards to the term “ANSI” not being part of the standard title as referenced throughout the UPC and UMC.

The action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for actions taken for Section 509.1 (Grease Removal Devices) and Section 517.3.1.1 (Equipment with Solid Fuel for Flavoring) with regard to the standard title reference within the codes.
Item #: 045

UMC 2021   Section: 601.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

601.0 General.

601.1 Applicability. Ducts and plenums that are portions of a heating, cooling, ventilation, or exhaust system shall comply with the requirements of this chapter, except as specified otherwise in Chapters 5 and 7.

SUBSTANTIATION:
Chapters 5 and 7 have specific requirements for specific types of ducts, such as grease ducts, product-conveying ducts, combustion air ducts, and laundry exhaust ducts. These specific requirements are critical for addressing the associated hazards involved with those types of systems. Several of the requirements included in Chapter 6 are not applicable to those installations, and, if followed, would result in an unsafe installation.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is not necessary as there are sections in Chapter 5 that require compliance with Chapter 6.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:   AFFIRMATIVE: 23   NEGATIVE: 2   NOT RETURNED: 1   HOWARD

EXPLANATION OF NEGATIVE:

HYDE: I believe this clarification would further clarify that the duct construction identified within Chapter 6 does not take precedence over duct construction identified in Chapters 5 and 7.

KOERBER: Adding this language would provide clarity between the applicable requirements in Chapters 5, 6, and 7.
Item #: 046

UMC 2021  Section: 601.2, Table 1701.1

SUBMITTER: David C. Bixby
Air Conditioning Contractors of America

RECOMMENDATION:
Revise text

601.0 General.

601.2 Sizing Requirements. Duct systems shall be sized in accordance with ACCA Manual D listed in Table 1701.1, or by other approved methods; zoned duct systems shall also comply with ACCA Manual Zr.

TABLE 1701.1
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: ACCA Manual Zr is a working draft and is not completed at the time of this monograph.

SUBSTANTIATION:
Currently there is no coverage in the UMC to address the design of zoned duct systems. ACCA Manual Zr provides procedures for designing zoned comfort systems for single family detached homes, duplex and triplex homes, row houses, town houses, and large multi-family structures that are compatible with ACCA Manual J procedures for residential load calculations. In addition, use of Manual Zr will avoid the potential for an improperly designed zoned duct system to adversely impact the safe operation and durability of the heating/cooling equipment. For code officials, Manual Zr has three normative sections to determine clear compliance. Manual Zr is also a consensus-based ANSI standard. The addition of ACCA Manual Zr is needed to support its proposed reference as a new requirement under 601.2. Manual Zr is a consensus-based ANSI standard that meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Projects.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposal is being rejected as ACCA Manual Zr is a working draft and is not completed at the time of this monograph.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

HYDE: I believe this Standard should be a referenced standard in conjunction with ACCA Manual D for all residential duct design systems that choose to "zone" their systems.
Item #: 047
UMC 2021  Section: 601.2, Table 1701.1

SUBMITTER: David C. Bixby
Air Conditioning Contractors of America

RECOMMENDATION:
Revise text

601.0 General.

601.2 Sizing Requirements. Duct systems shall be sized in accordance with ANSI/ACCA Manual D listed in Table 1701.1, or by other approved methods.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI/ACCA Manual D-2016</td>
<td>Residential Duct Systems</td>
<td>Ducts, Balancing</td>
<td>601.2</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The current reference to ACCA Manual D is updated to reflect its ANSI standard designation. This edition is unchanged from that currently referenced in the 2018 UMC.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is unnecessary as there are other standards that are also ANSI standards within the code that do not include ANSI in the title.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Proposals

Item #: 048

UMC 2021  Section: 601.2, 902.1, 1105.1, 1302.3

SUBMITTER: David Dias
                Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

601.0 General.

601.2 Sizing Requirements. Duct systems shall be sized in accordance with ACCA Manual D listed in Table 1701.1, or by other approved methods.

Exception: Residential duct systems shall be sized in accordance with ACCA Manual D listed in Table 1701.1, or by other approved methods.

902.0 General.

902.1 Nonindustrial Appliance. This chapter is applicable primarily to nonindustrial-type appliances and installations and, unless specifically indicated, does not apply to industrial-type appliances and installations. Listed appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions or, as elsewhere specified in this chapter, as applicable to the appliance. Unlisted appliances shall be installed as specified in this part as applicable to the appliances. For additional information concerning particular appliances and accessories, including industrial types, reference can be made to the standards listed in Chapter 17.

1105.0 General Requirements.

1105.1 Human Comfort. Cooling systems used for human comfort shall be in accordance with the return-air and outside-air provisions for furnaces in Section 904.7 and Section 904.8. Cooling equipment used for human comfort in dwelling units shall be selected to satisfy the calculated loads determined in accordance with the reference standards in Chapter 17 or other approved methods. Refrigerants used for human comfort shall be in accordance with Section 1104.6.

1302.0 Coverage of Piping System.

1302.3 Applications. This code shall not apply to the following items (reference standards for some of which appear in Chapter 17):

(remaining text unchanged)

SUBSTANTIATION:
In the 2018 edition of the UMC, Table 1701.1 has been split into two separate tables. Therefore, the existing reference to those tables must be revised to provide the proper standard for the applications. Section 601.2, Section 902.1, 1105.1, and Section 1302.3 are being revised to remove the reference to Table 1701.1 as it is unnecessary. All standards referenced in the body of the code are listed in Table 1701.1.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

601.0 General.

601.2 Sizing Requirements. Duct systems shall be sized in accordance with applicable standards in Chapter 17 ACCA Manual D or by other approved methods.

Exception: Residential duct systems shall be sized in accordance with ACCA Manual D listed in Table 1701.1, or by other approved methods.

902.0 General.

902.1 Nonindustrial Appliance. This chapter is applicable primarily to nonindustrial-type appliances and installations and, unless specifically indicated, does not apply to industrial-type appliances and installations. Listed appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions or, as elsewhere specified in this chapter, as applicable
1105.0 General Requirements.
1105.1 Human Comfort. Cooling systems used for human comfort shall be in accordance with the return-air and outside-air provisions for furnaces in Section 904.7 and Section 904.8. Cooling equipment used for human comfort in dwelling units shall be selected to satisfy the calculated loads determined. Refrigerants used for human comfort shall be in accordance with Section 1104.6.

1302.0 Coverage of Piping System.

1302.3 Applications. This code shall not apply to the following items:

(remaining text unchanged)

COMMITTEE STATEMENT:
The modification clarifies the intent of the code in regards to residential unit duct systems that are sized to ACCA Manual D.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25   NOT RETURNED: 1   HOWARD
Item #: 049
UMC 2021  Section: 602.2, Table 1701.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Add new text

602.0 Material.

602.2 Combustibles Within Ducts or Plenums. (remaining text unchanged)

602.2.6 Plastic Piping and Tubing in Plumbing Systems. Plastic piping and tubing used in plumbing systems shall be permitted to be used within a plenum if it exhibits a flame spread index of 25 or less and a smoke developed index of 50 or less when tested in accordance with ASTM E84 or UL 723, at full width of the tunnel and with no water or any other liquid in the pipe during the test, unless otherwise permitted by Section 602.2.6.1. [NFPA 90A 4.3.11.5.5.7]

602.2.6.1 Plastic Water Distribution Piping and Tubing. Plastic water distribution piping and tubing listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 5 ft (1.5 m) or less when tested in accordance with UL 2846, and installed in accordance with its listing, shall be permitted to be used within a plenum. [NFPA 90A 4.3.11.5.5.8]

### TABLE 1701.1
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 E84-2016</td>
<td>Surface Burning Characteristics of Building Materials</td>
<td>Miscellaneous</td>
<td>508.3.4, 602.2, 602.2.6, 604.1.2, 1201.2</td>
</tr>
<tr>
<td>UL 723-2008</td>
<td>Test for Surface Burning Characteristics of Building Materials (with revisions through August 12, 2013)</td>
<td>Miscellaneous</td>
<td>508.3.4, 602.2, 602.2.6, 604.1.2, 1201.2</td>
</tr>
<tr>
<td>UL 2846-2014</td>
<td>Fire Test of Plastic Water Distribution Plumbing Pipe for Visible Flame and Smoke Characteristics (with revisions through December 20, 2016)</td>
<td>Miscellaneous</td>
<td>602.2.6.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ASTM E84, UL 723, and UL 2846 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The 2018 edition of NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, which is an ANSI standard, provides specific requirements for the installation in plenums for plastic piping and tubing used in plumbing systems. NFPA 90A also permits the installation of plastic water distribution piping and tubing in plenums, where tested in accordance with UL 2846. This proposal is a direct extract from NFPA 90A. UL 2846 is an ANSI standard that includes 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 that can be installed in ducts, plenums, and other spaces used for environmental air. The scope of this standard can be viewed at http://ulstandards.ul.com/standard/?id=2846. The acceptance criteria specified (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) is consistent with values in Sections 602.2.1, 602.2.2 and 602.2.3.

COMMITTEE ACTION: REJECT
COMMITTEE STATEMENT:
The proposed change is being rejected based on the action taken on Item # 051. Furthermore, the proposed language addresses requirements that belong in a standard rather than in the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 5  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

CUDAHY: While I prefer the approach in Item # 050, at least this introduces UL 2846. Vote to overturn Item # 050.

EGG: It seems the new language improves the code.

KOERBER: I believe this proposal, placing into the code, the requirements from the NFPA standard makes sense.

MACNEVIN: The proposed new language improves the code. UL 2846 is the most appropriate test method for plastic pipes for mechanical or plumbing applications. This proposal accurately adds reference to UL 2846, and includes appropriate requirements for safe installation of these materials within plenums.

A. TRAFTON: The new language improves the code.
Item #: 050

UMC 2021  Section: 602.2, Table 1701.1

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

RECOMMENDATION:
Add new text

602.0 Material.

602.2 Combustibles Within Ducts or Plenums. (remaining text unchanged)
(1) - (8) (remaining text unchanged)
(9) Plastic water distribution piping and tubing listed and labeled for use in plenums with a flame spread distance not exceeding 5 feet (1524 mm), an average optical density not exceeding 0.15, and a peak optical density not exceeding 0.5, where tested in accordance with UL 2846.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
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<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 2846-2014</td>
<td>Fire Test of Plastic Water Distribution Plumbing for Visible Flame and Smoke Characteristics (with revisions through December 20, 2016)</td>
<td>Plastic Piping</td>
<td>602.2(9)</td>
</tr>
</tbody>
</table>

Note: UL 2846 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
UL 2846 is a valid published consensus standard, already included in the IMC code in a similar manner. It should also be present in the UMC for consistency. UL 2846 is a testing standard separate, though similar to ASTM E84, and contains the required mounting requirements for distribution piping, similar to fire sprinkler piping. There are no issues or conflicts between the standards. ANSI/UL2846 was developed by experts in this area through an ANSI consensus process. This included Authorities Having Jurisdiction, Manufacturers, Testing Organizations, and Supply Chain. Relative to other Standards development efforts, there was little "controversy" over the creation of ANSI/UL 2846. In fact, the Standard successfully passed the ANSI balloting process on the first process attempt with a final vote of 83 percent affirmative - well in excess of the required 2/3 vote. Many products have alternative standards in this section of the code, including NFPA 70, NFPA 262, UL 1887, UL 1820, and UL 2043. PPFA recommends that this item be accepted as submitted.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is being rejected based on the action taken on Item # 051.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 5  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
CUDAHY: I am voting AGAINST the committee action to reject on this item from the meeting. The UL 2846 standard is a consensus standard by UL, and is already in another model mechanical code a full cycle. Codes should adopt testing standards made specifically for items that follow the required process. ASTM E84 is a general test for any product and, therefore, there are alternative standards designed for testing many products with morphologies similar to pipe – such
as wire, pneumatic tubing, and fire sprinklers already in the codes. This item does not conflict with any other proposal items. There was some confusing discussion during the item, but UL 2846 is a dry test, no water. Therefore, vote AGAINST the committee action on Item # 050 to overturn.

EGG: The new language improves the code.

KOERBER: Reference to the standard should be included.

MACNEVIN: The proposed new language improves the code. UL 2846 is the most appropriate test method for plastic pipes for mechanical or plumbing applications. This proposal accurately adds reference to UL 2846, and includes appropriate requirements for safe installation of these materials within plenums.

A. TRAFTON: Reference to the standard should be included.
Item #: 051
UMC 2021  Section: 602.2

SUBMITTER: Brian Helms
Charlotte Pipe and Foundry

RECOMMENDATION:
Revise text

602.0 Material.

602.2 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. Plastic piping installed in plenums shall be tested in accordance with all requirements of ASTM E84 or UL723. Mounting methods, supports and sample sizes of materials for testing that are not specified in ASTM E84 or UL 723 shall be prohibited.

Note: ASTM E84 and UL 723 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
A growing issue in the plumbing industry is that the ASTM E 84 test protocol is being modified to test combustible piping materials. At the direction of plastics manufacturers, test labs will modify mounting methods, supports and test specimen dimensions to achieve results that are in compliance with the 25/50 benchmarks the code requires. These results are then used to secure a listing by third party certifiers to serve as proof to code officials of compliance to the flame spread and smoke developed index requirements found in the code. The question of whether a piping material is in compliance to the flame spread and smoke developed requirements of the code is often further blurred as third party certifiers provide listings indicating that materials meet the 25/50 requirements using modified test methods. Third party certifiers disclose this information in their full listing or report, but this is not always easily identified or even accessible to officials. An inspector seeing ASTM E 84 on a pipe would likely assume that it meets the requirement of the code without fully knowing or understanding the restrictions that exist in the listing. In fact, listing agencies assume that the inspector will analyze the listing and make their own determination on compliance. This code change proposal provides notice to the official that simply adding the ASTM E 84 or UL 723 marking to the wall of the pipe does not necessarily mean that the product was tested in full compliance with the standard in the manner that the code intends. Charlotte Pipe has conducted ASTM E 84 tests at two different test facilities and found that results below the 25/50 flame spread and smoke developed index are not achievable when performed to the full requirements of ASTM E 84. Our testing has shown that CPVC and PVC piping will not consistently pass the ASTM E 84 without modification of the mounting method, supports or test specimen dimensions. If the practice of accepting modified test results is allowed to continue, then the requirements of the code will not be achieved. ASTM E 84 is a comparison test, and the 25/50 flame spread and smoke developed index is not a requirement of the standard, but of the code itself. If the 25/50 requirement is too restrictive, then an effort should be made to change the code. If the ASTM E 84 test method is flawed, change the standard. However, we can no longer allow the use of modified tests and third party listings to circumvent the requirements of the code which exist to preserve the health and safety of the public.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

VOTING RESULTS:  AFFIRMATIVE: 20  NEGATIVE: 5  ABSTAIN: 1

EXPLANATION OF NEGATIVE:

CUDAHY: This is poor code language and should not be specific to only plastic pipe or it would need to be repeated after every standard for every product. Urge rejection.

KOERBER: I agree with the intent of this proposal - to stop the potential "gaming" of the test standard in order to achieve the required values. Perhaps the wording is not the best and may not be enforceable but without spelling it out, what mechanism is in place to prevent this practice? If my memory serves, NFPA specifically indicates plastic piping tested across the full width of the tunnel and without water or other liquid in the piping. This indicates there is a concern for this happening.

MACNEVIN: The proposed new language is duplicative, redundant and confusing. The requirements for all materials, including plastic pipes, are already stated clearly in proper code language.

A. TRAFTON: This is poor code language. it does not help the code.

P. TRAFTON: In agreeance with the committee.
EXPLANATION OF ABSTAIN:

HOWARD: The referenced standard should be sufficient for enforcement. If the manufacturer opts to run contrary to the referenced standard then their product should be denied use by the AHJ.
Item #: 052

UMC 2021  Section: 602.2(5)

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

602.0 Material.

602.2 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.

Exceptions:

(1) - (4) (text unchanged)
(5) Products listed and labeled for installation within plenums in accordance with Section 602.2.1 through Section 602.2.3 602.2.4.
(6) - (8) (text unchanged)

SUBSTANTIATION:
The requirements of discrete products listed and labeled in accordance with UL 2043 as indicated in Section 602.2.4 (Discrete Products in Plenums) are also an exception to the requirement for these products to be noncombustible, or have a flame spread index not more than 25 and a smoke developed index not more than 50 where tested in accordance with ASTM E84 or UL 723.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change lacks technical reasoning to merit such a change.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
KOERBER: This proposal should be accepted as it properly refers to materials that should be allowed as they are listed to the appropriate standard.
Item #: 053
UMC 2021  Section: 602.2.5, Table 1701.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Add new text

602.0 Material.

602.2 Combustibles Within Ducts or Plenums. (remaining text unchanged)

602.2.5 Communications Raceways. Communications raceways shall be listed as having a maximum peak optical density of 0.50 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 5 feet (1524 mm) or less when tested in accordance with UL 2024. [NFPA 90A: 4.3.11.2.6.4]

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 2024-2014</td>
<td>Cable Routing Assemblies and Communications Raceways (with revisions through January 9, 2015)</td>
<td>Miscellaneous</td>
<td>602.2.5</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 2024 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
The 2018 edition of NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, which is an ANSI standard, also permits the installation of communication raceways in plenums, where tested in accordance with UL 2024. This proposal is a direct extract from NFPA 90A. The acceptance criteria specified (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) is consistent with values in Sections 602.2.1, 602.2.2 and 602.2.3.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is being rejected as communication raceways are not within the scope of the UMC.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 22  NEGATIVE: 3  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

HYDE: I believe that this would provide further clarity to the specific combustibles within the ducts/plenums for inspectors and installers.

KOERBER: I disagree with the committee action and statement. This requirement for communication cable raceways should be added to the chapter.

MACNEVIN: This addition is technically accurate and improves the code with additional requirements for polymer raceways.
CHAPTER 6
DUCT SYSTEMS

602.0 Material.

602.3 Metal. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Flexible metallic ducts shall comply with UL 181.

602.4 Nonmetallic Ducts. Nonmetallic ducts shall comply with Section 602.4.1, Section 602.4.2, Section 602.4.3 or Section 602.4.4.

602.4.1 Phenolic. Phenolic duct, plenum, or fitting material shall comply with UL 181. Ducts, plenums, or fittings of phenolic shall be constructed in accordance with SMACNA Phenolic Duct Construction Standards or the conditions of its listing.

602.4.2 Gypsum. Where gypsum products are exposed in ducts or plenums, the air temperature shall be restricted to a range from 50°F (10°C) to 125°F (52°C), and moisture content shall be controlled so that the material is not adversely affected. All gypsum products shall have a mold or mildew resistant surface. For the purpose of this section, gypsum products shall not be exposed in supply ducts.

602.4.3 Air Dispersion Systems. Air dispersion systems shall be listed and labeled in accordance with UL 2518.

602.4.4 Other Materials. Flexible and rigid ducts, plenums, or fittings for use in heating, ventilation, and air conditioning systems of other nonmetallic materials listed and labeled to UL 181 shall be permitted. Exception: Plastic ducts shall comply with Section 603.6.

602.6 Factory-Made Air Ducts. Factory-made air ducts shall be approved for the use intended or shall be in accordance with the requirements of UL 181. Each portion of a factory-made air duct system shall be identified by the manufacturer with a label or other identification indicating compliance with its class designation.

(renumber remaining sections)

603.0 Installation of Ducts.

603.1 General. Air ducts shall be installed in accordance with this Chapter and the installation instructions. The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

603.1.1 Pressure Classification. The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

603.1.2 Air Temperature. The temperature of the air to be conveyed in a duct shall not exceed 250°F (121°C).

603.1.3 Protection. Air ducts, other than plastic ducts, shall be installed with not less than 4 inches (102 mm) of separation from earth, except where installed as a liner inside of concrete, tile, or metal pipe and shall be protected from physical damage.

603.1.4 Vertical Risers. Ducts listed and labeled to UL 181 shall not be used for vertical risers in air-duct systems serving more than two stories.

603.1.5 Penetrations. Ducts listed and labeled to UL 181 shall not penetrate a fire-resistance-rated assembly or construction.

603.3 Metal Ducts. Ducts shall be supported at each change of direction and in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Riser ducts shall be held in place by means of metal straps or angles and channels to
secure the riser to the structure. Metal ducts shall be installed with not less than 4 inches (102 mm) separation from earth. Ducts shall be installed in a building with clearances that will retain the full thickness of fireproofing on structural members.

### 603.4 Factory-Made Air Ducts
Factory-made air ducts shall be listed and labeled in accordance with UL 181 and installed in accordance with the terms of their listing, the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Factory-made air ducts shall not be used for vertical risers in air-duct systems serving more than two stories and shall not penetrate a fire resistance rated assembly or construction.

Factory-made air ducts shall be installed with not less than 4 inches (102 mm) of separation from earth, except where installed as a liner inside of concrete, tile, or metal pipe and shall be protected from physical damage.

The temperature of the air to be conveyed in a duct shall not exceed 250°F (121°C). Flexible air connectors shall not be permitted.

### 603.4.1 Length Limitation
Factory-made flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

**Exception:** Residential occupancies.

(renumber remaining sections)

### 603.5 Flexible Air Ducts
Flexible air ducts shall comply with UL 181, and shall be installed in accordance with the manufacturer’s installation instructions and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Flexible air duct installations shall comply with the following:

1. Ducts shall be installed using the minimum required length to make the connection.
2. Horizontal duct runs shall be supported at not more than 4 feet (1219 mm) intervals.
3. Vertical risers shall be supported at not more than 6 feet (1829 mm) intervals.
4. Sag between support hangers shall not exceed \( \frac{1}{2} \) inch (12.7 mm) per foot (305 mm) of support spacing.
5. Supports shall be rigid and shall be not less than \( 1 \frac{1}{2} \) inches (38 mm) wide at point of contact with the duct surface.
6. Duct bends shall be not less than one duct diameter bend radius.
7. Screws shall not penetrate the inner liner of non-metallic flexible ducts unless permitted in accordance with the manufacturer’s installation instructions.
8. Fittings for attaching non-metallic ducts shall be beaded and have a collar length of not less than 2 inches (51 mm) for attaching the duct.
   **Exception:** A bead shall not be required where metal worm-gear clamps are used or where attaching metallic ducts using screws in accordance with the manufacturer’s installation instructions.
9. Duct inner liner shall be installed at not less than 1 inch (25.4 mm) on the collar and past the bead prior to the application of the tape and mechanical fastener. Where mastic is used instead of tape, the mastic shall be applied in accordance the mastic manufacturer’s instructions.
10. Duct outer vapor barriers shall be secured using two wraps of approved tape. A mechanical fastener shall be permitted to be used in place of, or in combination with, the tape.
11. Flexible air ducts shall not penetrate a fire-resistance rated assembly or construction.
12. The temperature of the air to be conveyed in a flexible air duct shall not exceed 250°F (121°C).
13. Flexible Air ducts shall be sealed in accordance with Section 603.10.

### 603.5.1 Length Limitation
Flexible air ducts shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

**Exception:** Residential occupancies.

### 603.5.2 Flexible Air Connectors
Flexible air connectors shall not be permitted.

### 603.8 Support of Ducts
Installers shall provide the manufacturer’s field fabrication and installation instructions. Factory-made air ducts that are in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Other ducts shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible or the manufacturer’s installation instructions.

### 603.10 Joints and Seams of Ducts
Joints and seams for duct systems shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Joints of duct systems shall be made substantially airtight by means of tapes, mastics, gasketing, or other means. Crimp joints for round ducts shall have a contact lap of not less than 1\( \frac{1}{2} \) inches (38 mm) and shall be mechanically fastened by means of not less than three sheet-metal screws equally spaced around the joint, or an equivalent fastening method.

### 603.10.1 Closure Systems
Joints and seams and reinforcements, for factory made air ducts and plenums listed and labeled to UL 181, shall comply with the conditions of prior approval be in accordance with the manufacturer’s installation instructions that shall accompany the product. Closure systems for sealing factory made air ducts and plenums shall be listed and labeled in
accordance with UL 181A or UL 181B, and marked in accordance with Table 603.10.1.

(renumber remaining sections)

604.0 Insulation of Ducts.

604.1 General. Air ducts conveying air at temperatures exceeding 140°F (60°C) shall be insulated to maintain an insulation surface temperature of not more than 140°F (60°C). Factory-made air ducts and insulations intended for installation on the exterior of ducts shall be legibly printed with the name of the manufacturer, the thermal resistance (R) value at installed thickness, flame-spread index, and smoke developed index of the composite material. Internal duct liners and insulation shall be installed in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.

(TABLE 1701.1 REFERENCED STANDARDS)

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
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<tbody>
<tr>
<td>UL 181-2013</td>
<td>Factory-Made Air Ducts and Air Connectors</td>
<td>Air Connectors, Air Ducts</td>
<td>602.3, 602.4.1, 602.4.4, 602.6, 603.1.4, 603.1.5, 603.4, 603.5, 603.8, 603.10.1, 604.1.1</td>
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<td>UL 2518-2005</td>
<td>Outline of Investigation for Air Dispersion Systems Materials</td>
<td>Duct Systems</td>
<td>602.4.3, 603.13</td>
</tr>
<tr>
<td>SMACNA-2006</td>
<td>HVAC Duct Construction Standards Metal and Flexible, 3rd Edition</td>
<td>Ducts, Metal and Flexible</td>
<td>504.4.5, 506.2, 602.3, 603.3, 603.4, 603.5, 603.8, 603.10, 603.12, 604.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 181 and UL 2518 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The term “factory-made air ducts” is vague and ambiguous in regard to which products are included within the category. Therefore, the appropriate materials have been added to Section 602.3-602.4, and the specific installation requirements have been added to Section 603.1 for clarity. Section 603.4 (Factory Made Air Ducts) has been split into two categories; Section 602.3 (Metallic) and Section 602.4 (Nonmetallic). Section 602.3 will provide the minimum requirements for metallic ducts. Section 602.4 specifies the requirements for phenolic, gypsum and other materials. The phrase “Metal ducts shall be installed with not less than 4 inches (102 mm) separation from earth” is being removed from Section 603.3, since this requirement is already stated under the new general Section 603.1.3 (Protection), which applies to all duct materials except plastic ducts. Section 603.4.1 (Length Limitation) has been relocated under the “Flexible Air Ducts” section, as this requirement only applies to flexible air ducts. Section 603.8 (Support of Ducts) is being modified for clarity as all air ducts are supported in accordance with SMACNA or the manufacturer’s installation instructions, not only air ducts that are in accordance with UL 181. Section 603.10 (Joints and Seams of Ducts) was separated into its own respective section, 603.10.1 (Closure Systems), as closure systems have unique requirements that do not necessarily apply to joints and seams. Under Section 604.1, the term “factory-made air ducts” is being removed, as these insulation requirements apply to all air ducts.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 055

UMC 2021 Section: 602.6, Table 1701.1

SUBMITTER: William Chapin
Professional Code Consulting, LLC

RECOMMENDATION:
Revise text

602.0 Material.

602.6 Fiberglass Reinforced Plastic (FRP). Fiberglass Reinforced Plastic (FRP) duct, plenum, or fitting material shall comply with UL 181 and shall be constructed in accordance with SMACNA Thermoset FRP Duct Construction Manual Standards.

(renumber remaining sections)

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<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<td>Thermoset FRP Duct Construction Manual</td>
<td>Ducts</td>
<td>602.6</td>
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(portion of table not shown remains unchanged)

Note: UL 181 and SMACNA Thermoset FRP Duct Construction Manual meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
Statement of Problem and Substantiation/Resolution: ANSI/SMACNA 011-2017 contains language, tables, and details for the construction of hand lay-up, spray-up, and filament wound FRP ductwork from 30 inch wg negative pressure to 30 inch wg positive pressure. Round ductwork sizes are expanded to include up to 96 inches diameter. Adding these additional construction standards was discussed during the "Factory Made Duct" Task Group meetings but was decided it was outside the scope of the task group. The benefit of these additions is reducing the number of materials that fall under "other materials" and gives manufacturers, installers and code officials clear and consistent requirements.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The FRP standard does not contain mandatory requirements. Furthermore, UL 181 can be used in other applications.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 23 NEGATIVE: 1 ABSTAIN: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:
KOERBER: I agree with the intent of the proposal.

EXPLANATION OF ABSTAIN:
SMITH: The proposed language seems acceptable but more research needed.
Item #: 056
UMC 2021  Section: 602.7, Table 1701.1

SUBMITTER: William Chapin
Professional Code Consulting, LLC

RECOMMENDATION:
Revise text

602.0 Material.

602.7 Thermoplastics. Thermoplastic (PVC) duct, plenum, or fitting material shall comply with UL 181 and shall be constructed in accordance with SMACNA Thermoplastic Duct (PVC) Construction Manual Standards.

(renumber remaining sections)

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<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<td>UL 181-2013</td>
<td>Factory-Made Air Ducts and Air Connectors</td>
<td>Air Connectors, Air Ducts</td>
<td>602.6, 602.7, 603.4, 603.5, 603.8, 604.1.1</td>
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Note: UL 181 and SMACNA Thermoplastic Duct (PVC) Construction Manual meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
Statement of Problem and Substantiation/Resolution: The SMACNA Thermoplastic manual gives guidance in understanding these synthetic materials, as well as assistance in determining their strengths and corrosion resistance. A model specification enables one to easily prepare custom project documents for installation of PVC air handling systems. Also covered are polypropylene and polyethylene, CPVC, LDPE, HDPE, UHMW, ABS, Acrylics, and PVDF. Adding these additional construction standards was discussed during the "Factory Made Duct" Task Group meetings but was decided it was outside the scope of the task group. The benefit of these additions is reducing the number of materials that fall under "other materials" and gives manufacturers, installers and code officials clear and consistent requirements.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The SMACNA standard for thermoplastic ducts does not contain mandatory requirements. Furthermore, UL 181 can be used in other applications.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
KOERBER: I agree with the intent of the proposal.
Item #: 057

UMC 2021  Section: 603.4.1, 603.5(6)

SUBMITTER: Stan Rusek, PE
Quietflex MFG

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.4 Factory-Made Air Ducts. (remaining text unchanged)

603.4.1 Length Limitation. Factory made flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

Exception: Residential occupancies.

603.5 Flexible Air Ducts. Flexible air ducts shall comply with UL 181, and shall be installed in accordance with the manufacturer’s installation instructions and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Flexible air duct installations shall comply with the following:

(1) Ducts shall be installed using the minimum required length to make the connection.
(2) Horizontal duct runs shall be supported at not more than 4 feet (1219 mm) intervals.
(3) Vertical risers shall be supported at not more than 6 feet (1829 mm) intervals.
(4) Sag between support hangers shall not exceed ½ inch (12.7 mm) per foot (305 mm) of support spacing.
(5) Supports shall be rigid and shall be not less than ½ inch (13 mm) wide at point of contact with the duct surface.
(6) Duct bends shall not be used in lieu of rigid elbows or fittings except as an elbow at a terminal device.

Exception: Residential occupancies.

(67) Duct bends shall be not less than one duct diameter bend radius.
(78) Screws shall not penetrate the inner liner of non-metallic flexible ducts unless permitted in accordance with the manufacturer’s installation instructions.
(89) Fittings for attaching non-metallic ducts shall be beaded and have a collar length of not less than 2 inches (51 mm) for attaching the duct.

Exception: A bead shall not be required where metal worm-gear clamps are used or where attaching metallic ducts using screws in accordance with the manufacturer’s installation instructions.

(410) Duct inner liner shall be installed at not less than 1 inch (25.4 mm) on the collar and past the bead prior to the application of the tape and mechanical fastener. Where mastic is used instead of tape, the mastic shall be applied in accordance the mastic manufacturer’s instructions.
(411) Duct outer vapor barriers shall be secured using two wraps of approved tape. A mechanical fastener shall be permitted to be used in place of, or in combination with, the tape.
(412) Flexible air ducts shall not penetrate a fire-resistancerated assembly or construction.
(413) The temperature of the air to be conveyed in a flexible air duct shall not exceed 250°F (121°C).
(414) Flexible Air ducts shall be sealed in accordance with Section 603.10.

SUBSTANTIATION:
Flexible ducts in commercial applications that are installed per the requirements of Section 603.5 should not have an arbitrary maximum length limit of 5 feet. Properly installed ducts perform satisfactorily without the need for this limitation. The Air Duct Council initiated laboratory testing to demonstrate comparative performance when flexible ducts are installed at double the length allowed in 603.4.1 bringing into question the necessity for such a limit in the UMC.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Reject in favor of the action taken on Item # 054 in regards to the length limitation of flexible air ducts.
TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:

KOERBER: Although affirmation of Item # 054 took precedent to uphold the work done by the UMC Factory-made Duct Task Group, this proposal in Item # 057 deserves further discussion and approval since the 5 foot limit for flexible duct in commercial applications is not warranted with the added language for flex installations in Section 603.5 during the 2018 code cycle.
Item #: 058
UMC 2021  Section: TIA 005-15, 603.4.1

SUBMITTER: David Dias (Sheet Metal Workers’ Local Union 104), Eli Howard (SMACNA)

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.4.1 Length Limitation. Factory-made flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. **Flexible air ducts shall be permitted to be used as an elbow at a terminal device.**

Exception: Residential occupancies.

SUBSTANTIATION:
Technical Merit: The original proposal and TC discussion on flexible duct focused on the need to eliminate the use of flexible duct in lieu of rigid elbows for the purposes of changing direction in runs of ductwork. It was neither the intent of the proposer nor did the data provided to the TC justify the inclusion of a rigid elbow requirement for terminal connections. The language adopted by the TC in 603.4.1 is incomplete and is being misinterpreted as such to require the mandated use of a rigid elbow for terminal connections. The use of flexible duct for terminal connections is in fact appropriate as long as it is installed in compliance to the UMC and SMACNA HVAC Duct Construction Standard. Further, the use of flexible duct for terminal connections uniquely allows for the proper sound attenuation to be maintained at the terminal airflow exit to the conditioned space. Emergency Nature: Proposers and IAPMO technical committee never intended during adoption for this to be read as a ban on the use of flexible duct for connections to terminals and/or registers. Enforcement confusion in the field is leading to unnecessary costs and penalties to contractors and customers. Designers/Commissioning Agents have also been impacted over the proper method to specify the connection and length of flexible duct for final connections to the terminals and/or registers.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
Reject in favor of the action taken on Item # 054 as the proposed language is already included as part of Item # 054.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  ABSTAIN: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF ABSTAIN:
KOERBER: This language is already part of Section 603.4.1 based on the TIA.
Item #: 059

UMC 2021  Section: 603.4.1

SUBMITTER: Jeremy Martinez  
Golden Gate Chapter ASHRAE  
Rep: ASHRAE

RECOMMENDATION:  
Revise text

603.0 Installation of Ducts.

603.4 Factory-Made Air Ducts. (remaining text unchanged)

603.4.1 Length Limitation. Factory-made flexible air ducts and connectors shall be not more than \(5.7\) feet (1724 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

Exception: Residential occupancies.

SUBSTANTIATION:  
7 feet is a common recommendation of acoustical engineers to allow the flex duct to attenuate noise generated by balancing dampers. Impact on pressure drop will be negligible.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:  
Reject in favor of action taken on Item # 054 in regards to the length limitation of flexible air ducts. Furthermore, there was no technical reason provided to warrant such change.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  
AFFIRMATIVE: 22  NEGATIVE: 3  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

KOERBER: Although affirmation of Item # 054 took precedent to uphold the work done by the UMC Factory-made Duct Task Group, this proposal in Item # 057 deserves further discussion and approval since the 5 foot limit for flexible duct in commercial applications is not warranted with the added language for flex installations in Section 603.5 during the 2018 code cycle.

A. TRAFTON: The length of 7’ is a standard length recommended for acoustics.

P. TRAFTON: The length of 7’ is better for acoustics.
Item #: 060
UMC 2021 Section: 603.5

SUBMITTER: Randy Young
Sacramento JATC

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.5 Flexible Air Ducts. Flexible air ducts shall comply with UL 181, and shall be installed in accordance with the manufacturer’s installation instructions and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Flexible air duct installations shall comply with the following:
(1) Ducts shall be installed using the minimum required length to make the connection.
(2) Horizontal duct runs shall be supported at not more than 4 feet (1219 mm) intervals.
(3) Vertical risers shall be supported at not more than 6 feet (1829 mm) intervals.
(4) Sag between support hangers shall not exceed 1/2 inch (12.7 mm) per foot (305 mm) of support spacing.
(5) Supports shall be rigid and shall be not less than 1 1/2 inches (38 mm) wide at point of contact with the duct surface.
(6) Duct bends shall be not less than one duct diameter bend radius.
(7) Screws shall not penetrate the inner liner of non-metallic flexible ducts unless permitted in accordance with the manufacturer’s installation instructions.
(8) Fittings for attaching non-metallic ducts shall be beaded and have a collar length of not less than 2 inches (51 mm) for attaching the duct.

Exception: A bead shall not be required where metal worm-gear clamps are used or where attaching metallic ducts using screws in accordance with the manufacturer’s installation instructions.

(9) Duct inner liner shall be installed at not less than 1 inch (25.4 mm) on the collar and past the bead prior to the application of the tape and mechanical fastener. Where mastic is used instead of tape, the mastic shall be applied in accordance the mastic manufacturer’s instructions.
(10) Duct outer vapor barriers shall be secured using two wraps of approved tape. A mechanical fastener shall be permitted to be used in place of, or in combination with, the tape.
(11) Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction.
(12) The temperature of the air to be conveyed in a flexible air duct shall not exceed 250°F (121°C).
(13) Flexible Air ducts shall be sealed in accordance with Section 603.10.

SUBSTANTIATION:
All fittings where flexible duct is attached to the duct system shall have a bead to prohibit or stop the flexible duct from coming off the fitting.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The submitter requested for this proposal to be rejected.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 061
UMC 2021  Section: 603.5

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.5 Flexible Air Ducts. Flexible air ducts shall comply with UL 181, and shall be installed in accordance with the manufacturer’s installation instructions and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Flexible air duct installations shall comply with the following:

(1) - (7) (remaining text unchanged)

(8) Fittings for attaching non-metallic ducts shall be beaded and have a collar length of not less than 2 inches (51 mm) for attaching the duct. Metal worm-gear clamps shall be used.

Exception: A bead shall not be required where metal worm-gear clamps are used or where attaching metallic ducts using screws in accordance with the manufacturer’s installation instructions.

SUBSTANTIATION:
Beads should always be used to prevent the flexible duct from slipping off the metal fitting. Metal clamps should be required because there are too many nonmetallic clamps being installed that are not UL listed which makes it very hard for a building official to catch and enforce.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:

KOERBER: Requiring use of beaded fittings and metallic clamps is overly restrictive.
Item #: 062
UMC 2021  Section: 603.8 - 603.8.3, Table 1701.1

SUBMITTER: David Dias  
Sheet Metal Workers Local 104

RECOMMENDATION:  
Revise text

603.0 Installation of Ducts.

603.8 Support of Ducts.  Installers shall provide the manufacturer’s field fabrication and installation instructions.  
Factory made air ducts that are in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions.  
Other ducts shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible.  Ducts shall be supported in accordance with the manufacturer’s installation instructions; and Section 603.8.1, Section 603.8.2 or Section 603.8.3.

603.8.1 Metal Ducts.  Ducts shall be supported at each change of direction and in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.  Riser ducts shall be held in place by means of metal straps or angles and channels to secure the riser to the structure.

603.8.1.1 Rectangular Ducts.  Supports for rectangular ducts shall be installed on two opposite sides of each duct and shall be riveted, bolted, or metal screwed to each side of the duct at intervals specified.

603.8.1.2 Horizontal Round Ducts.  Horizontal round ducts not more than 40 inches (1016 mm) in diameter where suspended from above shall be supported with one hanger per interval and in accordance with Section 603.3.2.1 through Section 603.3.2.3.

603.8.1.3 Tight-Fitting Around the Perimeter.  Ducts shall be equipped with tight-fitting circular bands extending around the entire perimeter of the duct at each specified support interval.

603.8.1.4 Size of Circular Bands.  Circular bands shall be not less than 1 inch (25.4 mm) wide nor less than equivalent to the gauge of the duct material it supports.

Exception: Ducts not more than 10 inches (254 mm) in diameter shall be permitted to be supported by No. 18 gauge galvanized steel wire.

603.8.1.5 Connection.  Each circular band shall be provided with means of connecting to the suspending support.

603.8.2 Flexible Air Ducts.  Flexible air ducts shall be supported in accordance with Section 603.5.

603.8.3 Other Ducts.  Other approved ducts shall be supported in accordance with the manufacturer’s installation instructions.

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<tr>
<th>TABLE 1701.1</th>
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<td>SMACNA-2017</td>
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(portion of table not shown remains unchanged)

Note: SMACNA HVAC Duct Construction Standards – Metal and Flexible meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The support requirements are being relocated into one section for ease of use of the code.  Currently, there are duct support requirements throughout Chapter 6 which causes confusion in the field for the AHJ to enforce.  There has been no language removed, it has only been relocated into Section 603.8 for supports.  Section 603.8.2 refers the end user to the proper section for support of flexible air ducts.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 063

UMC 2021  Section: 603.10.1

SUBMITTER: Jeremy Martinez
Golden Gate Chapter ASHRAE
Rep: ASHRAE

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.10 Joints and Seams of Ducts. (remaining text unchanged)
603.10.1 Duct Leakage Tests. Ductwork that is designed to operate at static pressures in excess of 3 inches of water column (0.7 kPa) and all ductwork located outdoors shall be leak-tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual. Representative sections totaling not less than 10 percent of the total installed duct area shall be tested. Where the tested 10 percent fail to comply with the requirements of this section, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fail to comply with the requirements of this section, then 100 percent of the total installed duct area shall be tested. Sections shall be selected by the building owner or designated representative of the building owner. Positive pressure leakage testing shall be permitted for negative pressure ductwork. The permitted duct leakage shall be not more than the following:

(remaining text unchanged)

SUBSTANTIATION:
The current requirement calls for leakage testing of all ductwork. This is onerous and not cost effective. The proposed wording is to make the requirement consistent with ASHRAE Standard 90.1.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
All ductwork should be tested, not only ductwork located outdoors or in excess of three inches of water column.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 064
UMC 2021  Section: 603.11, Table 1701.1

SUBMITTER: Jeremy Martinez
Golden Gate Chapter ASHRAE
Rep: ASHRAE

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.11 Cross Contamination. Exhaust ducts that convey Class 4 air shall be negatively pressurized relative to ducts, plenums, or occupiable spaces through which the ducts pass. Exhaust ducts and venting systems under positive pressure that convey Class 2 or Class 3 air shall not extend into or pass through ducts, or plenums, or occupiable spaces other than the space from which the exhaust air is drawn. Exception: Exhaust ducts conveying Class 2 air and exhaust ducts conveying air from residential kitchen hoods that are sealed in accordance with SMACNA Seal Class A. [ASHRAE 62.1:5.2.1, 5.2.2]

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<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<td>SMACNA-2012</td>
<td>HVAC Air Duct Leakage Test Manual, 2nd Edition</td>
<td>Ducts</td>
<td>603.10.1, 603.11</td>
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(portion of table not shown remains unchanged)

Note: SMACNA HVAC Air Duct Leakage Test Manual, 2nd Edition meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
To make wording consistent with Section 5.2 of ASHRAE Standard 62.1-2016.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 065

UMC 2021  Section: 603.14 - 603.14.6

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

603.0 Installation of Ducts.

603.14 Clearances. Duct clearances shall be in accordance with Section 603.14.1 through Section 603.14.6.
603.14.1 General. Duct clearances to combustible construction shall be in accordance with the listing and the manufacturer’s installation instructions.

904.2.7 603.14.2 Supply Air Ducts To Listed Furnaces. Supply air ducts connecting to listed central heating furnaces shall have the same minimum clearance to combustibles as required for the furnace supply plenum for a distance of not less than 3 feet (914 mm) from the supply plenum. Clearance shall not be required beyond the 3 feet (914 mm) distance. [NFPA 54:10.3.2.7]

904.2.8 603.14.3 Supply Air Ducts to Unlisted Furnaces. Supply air ducts connecting to unlisted central heating furnaces equipped with temperature limit controls with a maximum setting of 250°F (121°C) shall have a minimum clearance to combustibles of 6 inches (152 mm) for a distance of not less than 6 feet (1829 mm) from the furnace supply plenum. Clearance shall not be required beyond the 6 feet (1829 mm) distance. [NFPA 54:10.3.2.8]

903.2.5 603.14.4 Furnace Plenums and Air Ducts. A furnace plenum supplied as a part of the air-conditioning appliance shall be installed in accordance with the manufacturer’s instructions. Where a furnace plenum is not supplied with the appliance, any fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate proper circulation of air. Where the air conditioner is installed within an enclosure, the installation shall comply with Section 904.7.3. [NFPA 54:10.2.5]

603.14.5 Duct Furnaces. Duct Furnaces shall be installed in accordance with Section 905.0.
934.5.5 603.14.6 Hood and Duct Clearances Fuel-Burning Kilns. A hood and duct serving a fuel-burning kiln shall have a clearance from combustible construction of not less than 18 inches (457 mm). This clearance shall be permitted to be reduced in accordance with Table 303.10.1.

SUBSTANTIATION:
Chapter 6 currently does not address clearance requirements. The proposed modification will bring all the clearance requirements pertaining to duct systems in one chapter for ease of use of the documents.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Proposals

Item #: 066
UMC 2021  Section: 604.1.1, Table 1701.1

SUBMITTER:  Jay Peters  
Codes and Standards International  
Rep: Copper Development Association

RECOMMENDATION:  
Revise text

604.0 Insulation of Ducts.  
604.1 General. (remaining text unchanged)

604.1.1 Within Ducts or Plenums. Materials installed within ducts and plenums for insulating, sound deadening, or other purposes shall have a mold, humidity, and erosion-resistant surface where tested in accordance with UL 181. Duct liners in systems operating with air velocities exceeding 2000 feet per minute (10.16 m/s) shall be fastened with both adhesive and mechanical fasteners, and exposed edges shall have approved treatment to withstand the operating velocity. Where the internal insulation is capable of being in contact with condensates or other liquids, the material shall be water-resistant. Pipe and duct insulation shall not be used to reduce the maximum flame and smoke requirements in Section 602.2 unless tested in accordance with ASTM E84 or UL 723 as a composite assembly of the duct or pipe and its associated insulation, coatings and adhesives.

| TABLE 1701.1  
REFERENCED STANDARDS |
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<tr>
<td>STANDARD NUMBER</td>
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<tr>
<td>UL 723-2008</td>
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(portion of table not shown remains unchanged)

Note: ASTM E84 and UL 723 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
Fire walls, partitions, and similar protective assemblies are tested as composite assemblies, not as individual components. It is critical to have the best understanding possible of how an installed system will perform in the field which equates to replicating those conditions, especially in a plenum. This proposal clarifies that when materials do not meet minimum plenum safety requirements, simply covering them with plenum rated insulation may not be adequate protection, depending on the properties of the material being protected. Some insulation manufacturers market insulation materials for plenums, utilizing a "modified" E84 test, yet the code does not have provisions to use modified tests. Although there are insulation products that meet the flame and smoke requirements for plenums, the materials wrapped within them may begin to degrade, deteriorate and off-gas toxic fumes and substances into plenum spaces due to the high heat, even when protected. This off-gas could result in potential health and life-safety issues for occupants and first responders. All materials within plenums must meet the minimum plenum criteria and the code specifically identifies the proper tests. The IMC does not currently allow for "modified" test procedures in plenums.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
606.0 Ventilating Ceilings.

606.2 Requirements. Ventilating ceilings shall comply with the following:
(1) Suspended ventilating ceiling material shall have a Class 1 flame spread classification on both sides, determined in accordance with the building code. Suspended ventilating ceiling supports shall be of noncombustible materials.
(2) Lighting fixtures Luminaire recessed into ventilating ceilings shall be of a type approved for that purpose.

SUBSTANTIATION: NFPA 70 replaced the term “Lighting fixture(s)” with the term “Luminaires” in the 2002 edition. The term “Luminaire” is used internationally for these products. NFPA 70 defines “Luminaire” as: “Luminaire. A complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire.” By replacing the term “Lighting fixtures” with “Luminaires” the UMC will conform with the proper term used in NFPA 70 and the electrical industry.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 068

UMC 2021  Section: Chapter 7: 701.5, 701.7.3, 702.1

SUBMITTER: IAPMO Staff - Update Extracts
NFPA 54 Extract Update

RECOMMENDATION:
Revise text

701.0 General.

701.5 Indoor Opening Size and Location. Openings used to connect indoor spaces shall be sized and located in accordance with the following:
(1) Combining spaces on the same story. Each opening shall have a minimum free area of not less than 1 square inch per 1000 Btu/h (0.002 m²/kW) of the total input rating of all appliances in the space, but not less than 100 square inches (0.065 m²). One permanent opening shall commence within 12 inches (305 mm) of the top of the enclosure, and one permanent opening shall commence within 12 inches (305 mm) of the bottom of the enclosure (see Figure 701.5). The minimum dimension of air openings shall not be less than 3 inches (76 mm).
(2) Combining spaces in different stories. The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are connected by one or more permanent openings in doors or floors having a total minimum free area of not less than 2 square inches per 1000 Btu/h (0.004 m²/kw) of total input rating of all appliances. [NFPA 54:9.3.2.3]

701.7 Combination Indoor and Outdoor Combustion Air. (remaining text unchanged)

701.7.3 Outdoor Opening(s) Size. The outdoor opening(s) size shall be calculated in accordance with the following:
(1) The ratio of the interior spaces shall be the available volume of all communicating spaces divided by the required volume.
(2) The outdoor size reduction factor shall be one minus the ratio of interior spaces.
(3) The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with Section 701.6, multiplied by the reduction factor. The minimum dimension of air openings shall not be less than 3 inches (76 mm). [NFPA 54:9.3.4(3)]

702.0 Extra Device or Attachment.

702.1 General. No device or attachment shall be installed on any appliance that could in any way impair the combustion of gas. [NFPA 54:9.1.15]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Section 701.5, Section 701.7.3, and Section 702.1 are being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 069

UMC 2021 Section: Chapter 8: 802.2.1 - 803.2.13, Table 802.4, Table 1701.1

SUBMITTER: IAPMO Staff - Update Extracts NFPA 54 Extract Update

RECOMMENDATION:
Revise text

802.0 Venting of Appliances.

802.2.1 Appliances Not Required to be Vented. The following appliances shall not be required to be vented:
(1) Listed ranges.
(2) Built-in domestic cooking units listed and marked for optional venting.
(3) Listed hot plates and listed laundry stoves.
(4) Listed Type 1 clothes dryers exhausted in accordance with Section 504.4.
(5) A single listed booster-type (automatic instantaneous) water heater, when designed and used solely for the sanitizing rinse requirements of a dishwashing machine, provided that the appliance is installed with the draft hood in place and unaltered, if a draft hood is required, in a commercial kitchen having a mechanical exhaust system. [Where installed in this manner, the draft hood outlet shall not be less than 36 inches (914 mm) vertically and 6 inches (152 mm) horizontally from any surface other than the appliance.]
(6) Listed refrigerators.
(7) Counter appliances.
(8) Room heaters listed for unvented use.
(9) Direct gas-fired make-up air heaters.
(10) Other appliances listed for unvented use and not provided with flue collars.
(11) Specialized appliances of limited input such as laboratory burners or gas lights. [NFPA 54:12.3.2]

802.2.4 Ventilating Hoods. The use of ventilating hoods and exhaust systems shall be permitted to be used to vent appliances shall be limited to industrial appliances and appliances installed in commercial applications and to vent industrial appliances, particularly where the process itself requires fume disposal. [NFPA 54:12.3.3]

802.2.5 Well-Ventilated Spaces. The operation of flue gases from industrial-type appliances shall not be required to be vented to the outdoors where such that its flue gases are discharged directly into a large and well-ventilated industrial space shall be permitted. [NFPA 54:12.3.4]

802.3 Design and Construction. Venting systems shall be designed and constructed to convey all flue and vent gases to the outdoors. [NFPA 54:12.1]

802.3.3 Mechanical Draft Systems. Mechanical draft systems shall be listed in accordance with UL 378 and installed in accordance with both the appliance and the mechanical draft system manufacturer’s installation instructions. [NFPA 54:12.4.3.1]

802.3.3.2 Leakage. Forced draft systems and all portions of induced draft systems under positive pressure during operation shall be designed and installed so as to prevent leakage of flue or vent gases into a building. [NFPA 54:12.4.3.3]
802.3.4 Ventilating Hoods and Exhaust Systems. Ventilating hoods and exhaust systems shall be permitted to be used to vent appliances installed in commercial applications. [NFPA 54:12.4.4.1]

802.3.4.1 Automatically Operated Appliances. Where automatically operated appliances, other than commercial cooking appliances, are vented through a ventilating hood or exhaust system equipped with a damper or with a power means of exhaust, provisions shall be made to allow the flow of gas to the main burners where only when the damper is open to a position to properly vent the appliance and where when the power means of exhaust is in operation. [NFPA 54:12.4.4.21]

802.3.5 Circulating Air Ducts and Furnace Plenums. Venting systems shall not extend into or pass through a any fabricated air duct or furnace plenum. [NFPA 54:12.4.5.1]

802.4 Type of Venting System to be Used. The type of venting system to be used shall be in accordance with Table 802.4. [NFPA 54:12.5.1]

802.4.1 Plastic Piping. Where plastic piping is used to vent an appliance, the appliance shall be listed for use with such venting materials and the appliance manufacturer’s installation instructions shall identify the specific plastic piping material. The plastic pipe venting materials shall be labeled in accordance with the product standards specified by the appliance manufacturer or shall be listed and labeled in accordance with UL 1738. [NFPA 54:12.5.2]

802.4.2 Plastic Vent Joints. Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer’s installation instructions. Plastic pipe venting materials listed and labeled in accordance with UL 1738 shall be installed in accordance with the vent manufacturer's installation instructions. Where primer is required, it shall be of a contrasting color. [NFPA 54:12.5.3]

802.4.3 Special Gas Vent. Special gas vents shall be listed and labeled in accordance with UL 1738 and installed in accordance with the special gas vent manufacturer’s installation instructions. [NFPA 54:12.5.4]

### TABLE 802.4
**TYPE OF VENTING SYSTEM TO BE USED**
[NFPA 54: Table 12.5.1]

<table>
<thead>
<tr>
<th>APPLIANCES</th>
<th>TYPE OF VENTING SYSTEM</th>
<th>LOCATION OF REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed Category I appliances</td>
<td>Type B gas vent</td>
<td>Section 802.6</td>
</tr>
<tr>
<td>Listed appliances equipped with draft hood</td>
<td>Chimney</td>
<td>Section 802.5</td>
</tr>
<tr>
<td>Appliances listed for use with Type B gas vent</td>
<td>Single-wall metal pipe</td>
<td>Section 802.7</td>
</tr>
<tr>
<td></td>
<td>Listed chimney lining system for gas venting</td>
<td>Section 802.5.3</td>
</tr>
<tr>
<td></td>
<td>Special gas vent listed for these appliances</td>
<td>Section 802.4.3</td>
</tr>
<tr>
<td>Listed vented wall furnaces</td>
<td>Type B-W gas vent</td>
<td>Section 802.6, Section 907.0</td>
</tr>
<tr>
<td>Category II appliances, Category III appliances, and Category IV appliances</td>
<td>As specified or furnished by manufacturers of listed appliances</td>
<td>Section 802.4.1 and Section 802.4.3</td>
</tr>
<tr>
<td>Incinerators</td>
<td>Single-wall metal pipe</td>
<td>NFPA-82</td>
</tr>
<tr>
<td>Incinerators</td>
<td>In accordance with NFPA 82</td>
<td></td>
</tr>
<tr>
<td>Appliances that can be converted to use of solid fuel</td>
<td>Chimney</td>
<td>Section 802.5</td>
</tr>
<tr>
<td>Unlisted combination gas- and oil-burning appliances</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Combination gas- and solid-fuel-burning appliances
Appliances listed for use with chimneys only
Unlisted appliances

| Listed combination gas- and oil-burning appliances | Type L vent | Section 802.6
| Chimney | Section 802.5 |
| Decorative appliances in vented fireplace | Chimney | Section 911.2 |
| Gas-fired toilets | Single-wall metal pipe | Section 802.7, Section 929.3 |
| Direct-vent appliances | — | Section 802.6 |
| Appliances with integral vents | — | Section 802.7 |

802.5.3 Masonry Chimneys. Masonry chimneys shall be built and installed in accordance with NFPA 211 and lined with approved one of the following:

1. Approved clay flue lining, a listed.
2. A listed chimney lining system, or other listed and labeled in accordance with UL 1777.
3. Other approved material that resists corrosion, erosion, softening, or cracking from vent gases at temperatures not exceeding up to 1800°F (982°C).

Exception: Masonry chimney flues lined with a chimney lining system specifically listed for use with listed appliances with draft hoods, Category I appliances, and other appliances listed for use with Type B vents shall be permitted. The liner shall be installed in accordance with the liner manufacturer’s installation instructions. A permanent identifying label shall be attached at the point where the connection is to be made to the liner. The label shall read: “This chimney liner is for appliances that burn gas only. Do not connect to solid-or liquid-fuel-burning appliances or incinerators.” [NFPA 54:12.6.1.3]

802.5.7.2 Cleanouts. Cleanouts shall be examined to determine that and where they will do not remain tightly closed when not in use, they shall be repaired or replaced. [NFPA 54:12.6.4.3]

802.5.7.3 Existing Chimney. Where inspection reveals that an existing chimney is not safe for the intended application, it shall be repaired, rebuilt, lined, relined, or replaced with a vent or chimney in accordance with to conform to NFPA 211, and shall be approved suitable for the appliances to be attached. [NFPA 54:12.6.4.4]

802.5.8.3 Combination Gas- and Oil-Burning Appliances. A single chimney flue serving a listed combination gas- and oil-burning appliance shall be sized to properly vent in accordance with the appliance manufacturer’s instructions. [NFPA 54:12.6.5.4]

802.6.1 Termination Requirements Gas Vent Termination. A The termination of gas vents shall terminate in accordance with one of comply with the following requirements:

1. A gas vent shall terminate in accordance with one of the following:
   (a) Gas vents that are 12 inches (300 mm) or less in size and located not less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate above the roof in accordance with Figure 802.6.1 and Table 802.6.1.
   (b) Gas vents that are over 12 inches (300 mm) in size or are located less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate not less than 2 feet (610 mm) above the highest point where they pass through the roof and not less than 2 feet (610 mm) above a portion of a building within 10 feet (3048 mm) horizontally.
   (c) Industrial appliances as provided in Section 802.2.5.
   (d) Direct-vent systems as provided in Section 802.2.6.
   (e) Appliances with integral vents as provided in Section 802.2.7.
   (f) Mechanical draft systems as provided in Section 802.3.3 through Section 802.3.3.5.
   (g) Ventilating hoods and exhaust systems as provided in Section 802.3.4 and Section 802.3.4.1. [NFPA 54:12.7.2(1)]

2. 802.6.1.1 Type B and L Vents. A Type B or a Type L gas vent shall terminate not less than at least 5 feet (1524 mm) in vertical height above the highest connected appliance draft hood or flue collar. [NFPA 54:12.7.2(2)]

3. 802.6.1.2 Type B-W Vents. A Type B-W gas vent shall terminate not less than at least 12 feet (3658 mm) in vertical height above the bottom of the wall furnace. [NFPA 54:12.7.2(3)]

4. 802.6.1.3 Exterior Wall Termination. A gas vent extending through an exterior wall shall not terminate adjacent to the wall or below eaves or parapets, except as provided in Section 802.2.6 and Section 802.3.3 through Section 802.3.3.5. [NFPA 54:12.7.2(4)]
802.6.1.4 Decorative Shrouds. Decorative shrouds shall not be installed at the termination of gas vents except where such shrouds are listed for use with the specific gas venting system and are installed in accordance with the manufacturer’s installation instructions. [NFPA 54:12.7.2(5)]

802.6.1.5 Termination Cap. All gas vents shall extend through the roof flashing, roof jack, or roof thimble and terminate with a listed cap or listed roof assembly. [NFPA 54:12.7.2(6)]

802.6.1.6 Forced Air Inlet. A gas vent shall terminate at least 3 feet (914 mm) above a forced air inlet located within 10 feet (3048 mm). [NFPA 54:12.7.2(7)] [NFPA 54:12.7.3]

FIGURE 802.6.1
GAS-VENT TERMINATION LOCATIONS FOR GAS VENTS WITH LISTED CAPS 12 INCHES OR LESS IN SIZE NOT LESS THAN 8 FEET FROM A VERTICAL WALL [NFPA 54: FIGURE 12.7.2 12.7.3]

802.6.2 Size of Gas Vents. Venting systems shall be sized and constructed in accordance with Section 802.6.2.1 through Section 802.6.2.3 Section 803.0 or other approved engineering methods and the gas vent and the appliance manufacturer’s instructions. [NFPA 54:12.7.3]

802.7.3.1 Limitations. Single-wall metal pipe shall be used only for runs directly from the space in which the appliance is located through the roof or exterior wall to the outer air. A pipe passing through a roof shall extend without interruption through the roof flashing, roof jacket, or roof thimble. [NFPA 54:12.8.4.2]

802.7.3.2 Attic or Concealed Space. Single-wall metal pipe shall not originate in any unoccupied attic or concealed space and shall not pass through any attic, inside wall, concealed space, or floor. [NFPA 54:12.8.4.3]

802.7.3.5 Roof Thimble. Where a single-wall metal pipe passes through a roof constructed of combustible material, a noncombustible, nonventilating thimble shall be used at the point of passage. The thimble shall extend not less than at least 18 inches (457 mm) above and 6 inches (152 mm) below the roof with the annular space open at the bottom and closed only at the top. The thimble shall be sized in accordance with Section 802.7.3.4. [NFPA 54:12.8.4.5]

802.7.4 Size of Single-Wall Metal Pipe. Single-wall metal piping shall comply with the following requirements: Section 802.7.4.1 through Section 802.7.4.3. [NFPA 54:12.8.5]

(1) 802.7.4.1 Sizing of Venting System. A venting system of a single-wall metal pipe shall be sized in accordance with one of the following methods and the appliance manufacturer’s instructions:

(1a) For a draft hood-equipped appliance, in accordance with Section 803.0.

(1b) For a venting system for a single appliance with a draft hood, the areas of the connector and the pipe each shall not be less than the area of the appliance flue collar or draft hood outlet, whichever is smaller. The vent area shall not exceed be greater than seven times the draft hood outlet area.

(1c) Other approved engineering methods. [NFPA 54:12.8.5(1)]

(2) 802.7.4.2 Non-Round Metal Pipe. Where a single-wall metal pipe is used and has a shape other than round, it shall have an equivalent effective area equal to the effective area of the round pipe for which it is substituted; and the minimum internal dimension of the pipe shall be not less than 2 inches (51 mm). [NFPA 54:12.8.5(2)]

(3) 802.7.4.3 Venting Capacity. The vent cap or a roof assembly shall have a venting capacity not less than that of the pipe to which it is attached. [NFPA 54:12.8.5(3)]

802.7.5 Support of Single-Wall Metal Pipe. All portions of single-wall metal pipe shall be supported for the design and weight of the material employed. [NFPA 54:12.8.6]

802.8.2 Direct-Vent Appliance. The vent terminal of a clearances for through-the-wall direct-vent appliance with an input of 10
000 Btu/h (3 kW) or less vent terminals shall be located at least 6 inches (152 mm) from any air opening into a building, an appliance with an input over 10 000 Btu/h (14.7 kW) but not over 50 000 Btu/h (14.7 kW) shall be installed with a 9 inch (229 mm) vent termination clearance, and an appliance with an input exceeding 50 000 Btu/h (14.7 kW) shall have at least a 12 inch (305 mm) vent termination clearance in accordance with Table 802.8.2. The bottom of the vent terminal and the air intake shall be located at least not less than 12 inches (305 mm) above finished ground level. [NFPA 54:12.9.3]

### TABLE 802.8.2
**THROUGH-THE-WALL DIRECT VENT TERMINATION CLEARANCES**  
[NFPA 54: TABLE 12.9.3]

<table>
<thead>
<tr>
<th>DIRECT VENT APPLIANCE INPUT RATING</th>
<th>THROUGH THE WALL VENT TERMINAL CLEARANCE FROM ANY AIR OPENING INTO A BUILDING (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 000 Btu/hr and less</td>
<td>6</td>
</tr>
<tr>
<td>Greater than 10 000 Btu/hr and not exceeding 50 000 Btu/hr</td>
<td>9</td>
</tr>
<tr>
<td>Greater than 50 000 Btu/hr and not exceeding 150 000 Btu/hr</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 150 000 Btu/hr</td>
<td>In accordance with the appliance manufacturer’s instructions and in no case less than the clearances specified in Section 802.8.1.</td>
</tr>
</tbody>
</table>

For SI Units: 1 inch = 25.4 mm, 1000 British thermal units per hour=0.293 kW

#### 802.10.2.2 Size. Where two or more appliances are connected to a common vent or chimney, each vent connector shall be sized in accordance with Section 803.0 or other approved engineering methods. [NFPA 54:12.11.3.3]

As an alternative method applicable only where all of the appliances are draft hood-equipped, each vent connector shall have an effective area not less than the area of the draft hood outlet of the appliance to which it is connected. [NFPA 54:12.11.3.4]

#### 802.10.3.2 Pressure. Vent connectors serving Category I appliances shall not be connected to any portion of a mechanical draft system operating under positive static pressure, such as those serving Category III or Category IV appliances. [NFPA 54:12.11.4.3]

#### 802.10.4 Clearance. Minimum clearances from vent connectors to combustible material shall comply be in accordance with Table 802.7.3.3.

*Exception*: The clearance between a vent connector and combustible material shall be permitted to be reduced where the combustible material is protected as specified for vent connectors in Table 303.10.1. [NFPA 54:12.11.5]

#### 802.12.3 Additional Devices. Appliances requiring controlled chimney draft shall be permitted to be equipped with listed double-acting barometric draft regulators installed and adjusted in accordance with the manufacturer’s installation instructions. [NFPA 54:12.13.4]

#### 802.12.4 Location. Draft hoods and barometric draft regulators shall be installed in the same room or enclosure as the appliance in such a manner as to prevent a any difference in pressure between the hood or regulator and the combustion air supply. [NFPA 54:12.13.5]

#### 802.12.5 Positioning. Draft hoods and draft regulators shall be installed in the position for which they were designed with reference to the horizontal and vertical planes and shall be located so that the relief opening is not obstructed by a any part of the appliance or adjacent construction. The appliance and its draft hood shall be located so that the relief opening is accessible for checking vent operation. [NFPA 54:12.13.6]

#### 802.12.6 Clearance. A draft hood shall be located so that its relief opening is not less than 6 inches (152 mm) from a any surface except that of the appliance it serves and the venting system to which the draft hood is connected. Where a greater or lesser clearance is indicated on the appliance label, the clearance shall not be less than that specified on the label. Such clearances shall not be reduced. [NFPA 54:12.13.7]

#### 802.13 Manually Operated Dampers. A manually operated damper shall not be placed in an any appliance vent connector. Fixed baffles shall not be classified as manually operated dampers. [NFPA 54:12.14]

#### 802.14 Obstructions. Devices that retard the flow of vent gases shall not be installed in a vent connector, chimney, or vent. The following shall not be considered as obstructions:

1. Draft regulators and safety controls specifically listed for installation in venting systems and installed in accordance with the manufacturer’s installation instructions.
(2) Approved draft regulators and safety controls designed and installed in accordance with approved engineering methods.
(3) Listed heat reclaimers and automatically operated vent dampers installed in accordance with the manufacturer’s installation instructions.
(4) Vent dampers serving listed appliances installed in accordance with Section 803.1 or Section 803.2 or other approved engineering methods.
(5) Approved economizers, heat reclaimers, and recuperators installed in venting systems of appliances not required to be equipped with draft hoods, provided the appliance manufacturer’s installation instructions cover the installation of such a device in the venting system and performance in accordance with Section 802.3 and Section 802.3.1 is obtained. [NFPA 54:12.16]

803.0 Sizing of Category I Venting Systems.
803.1 Single Appliance Vent Table 803.1.2(1) through Table 803.1.2(6). Venting Table 803.1.2(1) through Table 803.1.2(6) shall not be used where obstructions are installed in the venting system. The installation of vents serving listed appliances with vent dampers shall be in accordance with the appliance manufacturer’s installation instructions or in accordance with the following:
(1) The maximum capacity of the vent system shall be determined using the “NAT Max” column.
(2) The minimum capacity shall be determined as though the appliance were a fan-assisted appliance, using the “FAN Min” column to determine the minimum capacity of the vent system. Where the corresponding “FAN Min” is “NA”, the vent configuration shall not be permitted and an alternative venting configuration shall be utilized. [NFPA 54:13.1.1]

803.1.14 Single Run of Vent. In a single run of vent or vent connector, more than one diameter and type shall be permitted to be used, provided that all the sizes and types are permitted by the tables. [NFPA 54:13.1.14]

803.2.10 High-Altitude Installations. Sea level input ratings shall be used when determining maximum capacity for high-altitude installation. Actual input (derated for altitude) shall be used for determining minimum capacity for high-altitude installation. [NFPA 54:13.2.11]

803.2.12 Vent Height. For multiple appliances all located on one floor, the available total height (H) shall be measured from the highest draft hood outlet or flue collar up to the level of the outlet of the common vent. [NFPA 54:13.2.13]
803.2.13 Multistory Installations. For multistory installations, the available total height (H) for each segment of the system shall be the vertical distance between the highest draft hood outlet or flue collar entering that segment and the centerline of the next higher interconnection tee. (See Figure 803.2.13) [NFPA 54:13.2.14] (See Figure 803.2.13)

99% Winter Design Temperatures for the Contiguous United States
This map is a necessarily generalized guide to temperatures in the contiguous United States. Temperatures shown for areas such as mountainous regions and large urban centers may not be accurate. The climate data used to develop this map are from the 1993 ASHRAE Handbook — Fundamentals (Chapter 24, Table 1: Climate Conditions for the United States).
For 99% winter design temperatures in Alaska, consult the ASHRAE Handbook — Fundamentals.
99% winter design temperatures for Hawaii are greater than 37°F
For SI units: °C = (°F-32)/1.8

FIGURE 803.1.2(6)
RANGE OF WINTER DESIGN TEMPERATURES USED IN ANALYZING EXTERIOR MASONRY CHIMNEYS IN THE UNITED STATES
[NFPA 54: FIGURE F.2.4]

TABLE 1701.1
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 378-2006</td>
<td>Draft Equipment (with revisions through September 17, 2013)</td>
<td>Fuel Gas, Appliances</td>
<td>802.15.1, 802.3.3</td>
</tr>
<tr>
<td>UL 1738-2010</td>
<td>Venting Systems for Gas-Burning Appliances Categories II, III, and IV (with revisions through November 7, 2014)</td>
<td>Fuel Gas, Appliances</td>
<td>802.4.1, 802.4.2, 802.4.3</td>
</tr>
<tr>
<td>NFPA 82-2014</td>
<td>Incinerators and Waste and Linen Handling Systems and Equipment</td>
<td>Incinerator Chutes</td>
<td>802.2.8, Table 802.4, 925.1</td>
</tr>
<tr>
<td>UL 1777-2015</td>
<td>Chimney Liners</td>
<td>Chimneys, Liners</td>
<td>802.5.3(2), 803.1.11.2</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 378, UL 1738, and UL 1777 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Chapter 8 is being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 070

UMC 2021  Section: 802.5.1.2, Table 1701.1

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

802.0 Venting of Appliances.

802.5 Masonry, Metal, and Factory-Built Chimneys.  (remaining text unchanged)

802.5.1 Factory-Built Chimneys.  (remaining text unchanged)

802.5.1.2 Listing Requirements.  Factory-built chimneys shall comply with the requirements of UL 103, or of UL 959 or UL 2561. Factory-built chimneys for use with wood-burning appliances shall comply with the Type HT requirements of UL 103. [NFPA 211:6.1.3.1, 6.1.3.2]

TABLE 1701.1
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 2561-2016</td>
<td>1400 Degree Fahrenheit Factory-Built Chimneys</td>
<td>Chimneys</td>
<td>802.5.1.2</td>
</tr>
</tbody>
</table>

Note: UL 2561 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
Section 802.5.1.2 is being revised to include the correct standard for factory-built chimneys. This is consistent with current industry standards.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD

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 3-4 of the Regulations Governing Committee Projects.

Actions taken on UMC Item # 070, Section 802.5.1.2 (Listing Requirements) resulted in conflicting language between UPC Item # 048, Section 509.5.1.2 (Listing Requirements). In order to correlate the language, the Technical Correlating Committee proposed the following modifications to the UMC:

802.0 Venting of Appliances.

802.5 Masonry, Metal, and Factory-Built Chimneys.  (remaining text unchanged)
802.5.1 Factory-Built Chimneys.  (remaining text unchanged)
802.5.1.2 Listing Requirements.  Factory-built chimneys shall comply with the requirements of UL 103, or UL 959 or UL 2561. Factory-built chimneys for use with wood-burning appliances shall comply with the Type HT requirements of UL 103. [NFPA 211:6.1.3.1, 6.1.3.2]
TCC ACTION:  ACCEPT AS SUBMITTED

TCC STATEMENT:  The language in UMC Item # 070, Section 802.5.1.2 (Listing Requirements) is being revised to correlate with the action taken by the UPC TC for Item # 048, Section 509.5.1.2 (Listing Requirements) regarding listing requirements for factory-built chimneys.

The action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for actions taken for Section 802.5.1.2 (Listing Requirements) with regards to listing requirements for factory-built chimneys.
Item #: 071

UMC 2021  Section: 901.1, Table 1701.1

SUBMITTER: Connor Barbaree
ASHRAE

RECOMMENDATION:
Revise text

901.0 General.

901.1 Applicability. This chapter addresses requirements for the design, construction, and installation of specific appliances. In addition to the requirements of this chapter, appliances shall comply with ASHRAE 188 and the general requirements of Chapter 3.

TABLE 1701.1
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>ASHRAE 188-2015</td>
<td>Legionellosis: Risk Management for Building Water Systems</td>
<td>Miscellaneous</td>
<td>901.1</td>
</tr>
</tbody>
</table>

Note: ASHRAE 188 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
ASHRAE Standard 188 was developed with the intent of providing code officials and building operators information on how to manage the risk of legionellosis. ASHRAE Standard 188 was published on June 26, 2015, and is now publicly available as a final, published ANSI Standard. ASHRAE Standard 188 (2018) has been in continuous maintenance, and several addenda have been approved and published, as well as improvements in code compatible language which will be incorporated into the published 2018 standard. There are many design considerations in the ASHRAE standard that will help minimize Legionella bacteria growth in building water systems which can lead to Legionnaires Disease when water droplets are aerosolized from shower heads, and other building water systems and fixtures that aerosolize water droplets. Following the ASHRAE Standard will minimize the risk of a Person contracting Legionnaires' disease. For more information on the standard, go here: http://www.techstreet.com/ashrae/products/1897561 See the following websites for more information: www.LegionellaPrevention.org, http://www.cdc.gov/legionella/about/ www.Legionella.com www.hcinfo.com http://www.who.int/water_sanitation_health/emerging/legionella.pdf

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is overly restrictive and contains provisions that are outside the scope of the UMC.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
P. TRAFTON: ASHRAE Standard 188 is an approved standard pertinent to this section.
Item #: 072

UMC 2021  Section: Chapter 9: 902.11 - 938.1, Table 1701.1

SUBMITTER: IAPMO Staff - Update Extracts
NFPA 54 Extract Update

RECOMMENDATION:
Revise text

902.0 General.
902.11 Combination of Appliances and Equipment. A any combination of appliances, equipment, attachments, or devices used together in a any manner shall be in accordance comply with the standards that apply to the individual appliance and equipment. [NFPA 54:9.1.21]

911.0 Decorative Appliances for Installation in Vented Fireplaces.

TABLE 911.2
FREE OPENING AREA OF CHIMNEY DAMPER FOR VENTING FLUE GASES FROM UNLISTED DECORATIVE APPLIANCES FOR INSTALLATION IN VENTED FIREPLACES
[NFPA 54: TABLE 10.6.2.3]

<table>
<thead>
<tr>
<th>CHIMNEY HEIGHT (feet)</th>
<th>MINIMUM PERMANENT FREE OPENING (square inches)*</th>
<th>APPLIANCE INPUT RATING (Btu/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7800</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>8400</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9000</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>9800</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>10 600</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>11 200</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

*The first six minimum permanent free openings [8 square inches (0.005 m²) to 51 square inches (0.03 m²)] correspond approximately to the cross-sectional areas of chimneys having diameters of 3 inches (76 mm) through 8 inches (203 mm), respectively. The 64 square inch (0.04 m²) opening corresponds to the cross-sectional area of a standard 8 inch (203 mm) by 8 inch (203 mm) chimney tile.

914.0 Non-Recirculating Direct Gas-Fired Industrial Air Heaters.
914.3 Installation. Non-recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer’s instructions. [NFPA 54:10.8.3.1]
914.3.1 Industrial or Commercial Occupancies. Non-recirculating direct gas-fired industrial air heaters shall be installed only in industrial or commercial occupancies. [NFPA 54:10.8.3.2]
914.4 Clearance from Combustible Materials. Non-recirculating direct gas-fired industrial air heaters shall be installed with a clearance from combustible materials of not less than that shown on the rating plate and the manufacturer’s installation instructions. [NFPA 54:10.8.4]

915.0 Recirculating Direct Gas-Fired Industrial Air Heaters.

915.3 Installation. Installation of direct gas-fired industrial air heaters shall comply with the following requirements:
(1) Recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer’s installation instructions.
(2) Recirculating direct gas-fired industrial air heaters shall be installed in industrial or commercial occupancies. [NFPA 54:10.9.3]

915.8 Purging. Inlet ducting, where used, shall be purged with not less than at least four air changes prior to an ignition attempt. [NFPA 54:10.9.8]

918.0 Food Service Appliance, Floor Mounted.
918.8 Ventilation. Means shall be provided to properly ventilate the space in which a food service appliance is installed to permit proper combustion of the gas. [NFPA 54:10.12.8]

920.0 Household Cooking Appliances.

920.4.3 Horizontal Clearance. The horizontal distance from the center of the burner head(s) of a listed top (or surface) cooking appliance to vertical combustible walls extending above the top panel shall be not less than that distance specified by the permanent marking on the appliance. [NFPA 54:10.15.2.3]

938.0 Compressed Natural Gas (CNG) Vehicular Fuel Systems.
938.1 General. The installation of compressed natural gas (CNG) fueling (dispensing) systems shall conform to NFPA 52. Residential CNG fueling appliances shall be listed in accordance with CSA NGV 5.1 and installed in accordance to the appliance manufacturer’s installation instructions. [NFPA 54:10.28]

**TABLE 1701.1**
**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>CSA NGV 5.1-2016</td>
<td>Residential Fueling Appliances</td>
<td>Appliances</td>
<td>938.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: CSA NGV 5.1 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

**SUBSTANTIATION:**
In accordance with IAPMO Governing Consensus Project, Section Chapter 9 is being revised to the latest edition of NFPA 54-2018.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 26
Item #: 073
UMC 2021  Section: 903.1, 1101.2, 220.0, Table 1701.1

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

903.0 Air-Conditioning Appliances.
903.1 Electric Air Conditioners. Electric air conditioning systems designed for permanent installation shall comply with UL 1995, UL 60335-2-24, or UL 60335-2-89.

1101.0 General. (remaining text unchanged)

1101.2 Equipment. Equipment for refrigerant recovery, recycling, or both shall comply with UL 1963. Group A2L refrigerants shall only be used in equipment that is listed and labeled in accordance with Section 903.1 for the specific A2L refrigerant.

CHAPTER 2
DEFINITIONS

220.0 – R –

Flammability Classification. Refrigerants shall be classified for flammability in accordance with one of the following:
Class 1. Refrigerants that do not show flame propagation where tested in air at 14.7 pound-force per square inch absolute (psia) (101 kPa) and 140°F (60°C).
Class 2. Refrigerants having a lower flammability limit (LFL) of more than 0.00625 pound per cubic foot (lb/ft³) (0.10012 kg/m³) at 140°F (60°C), 14.7 psia (101 kPa), and a heat of combustion of less than 8169 British thermal units per pound (Btu/lb) (1.8988 E+07 J/kg).
Class 2L. Indicates a refrigerant with lower flammability and a burning velocity of not more than 3.9 inches per second (0.099 m/s).

TABLE 1701.1
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 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>903.1</td>
</tr>
</tbody>
</table>

Note: UL 60335-2-24 and UL 60335-2-89 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.
SUBSTANTIATION:
Section 903.1 should be revised as only specific appliances can be used for refrigeration systems. UL 60335-2-24 and UL 60335-2-89 are appropriate for the application. Furthermore, 1101.2 should be revised to indicate that only those equipment listed for use with A2L refrigerants should be used. Lastly, a definition for 2L is required as it is currently not defined; the proposed definition will correlate with ASHRAE 34.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is outside the scope of the UMC and further research is needed with regards to A2L refrigerants before adding this provision to the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  ABSTAIN: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF ABSTAIN:
MACNEVIN: I am abstaining as the basis of rejection is not fully understood.
**Proposal**

**Edit Proposal**

**Item #: 074**

UMC 2021  Section: 904.7 - 904.7.3

**SUBMITTER:** David Dias  
Sheet Metal Workers Local 104

**RECOMMENDATION:**
Revise text

604.0 Furnace Plenums and Ducts Used in Fuel-Gas Appliances.  
904.7 604.1 Furnace Plenums and Air Ducts. Furnace plenums and air ducts shall be installed in accordance with this Chapter and NFPA 90A or NFPA 90B. [NFPA 54:10.3.7.1]

904.7.1 604.2 Supplied As a Part of Furnace. A furnace plenum supplied as a part of a furnace shall be installed in accordance with the manufacturer’s instructions. [NFPA 54:10.3.7.2]

904.7.2 604.3 Not Supplied With The Furnace. Where a furnace plenum is not supplied with the furnace, any fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate proper circulation of air. [NFPA 54:10.3.7.3]

904.7.3 604.4 Return Air. Where a furnace is installed so supply ducts carry air circulated by the furnace to areas outside the space containing the furnace, the return air shall also be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace. [NFPA 54:10.3.7.4]

(renumber remaining sections)

**SUBSTANTIATION:**
The UMC addresses provisions for plenums and air ducts. There is no reason to send the end user to NFPA 90A or NFPA 90B as Chapter 6 of the UMC addresses the minimum requirements for air ducts and plenums. Sending the end user to another document creates confusion for inspectors.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 075
UMC 2021  Section: 904.14, Table 1701.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION: 
Revise text

904.0 Central Heating Boilers and Furnaces.

904.14 Electric Central Furnaces. Electric central heating furnaces shall comply with UL 1995 or UL 60335-2-40 and shall be installed in accordance with the manufacturer’s installation instructions.

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

(portions of table not shown remain unchanged)

Note: UL 60335-2-40 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
UL 60335-2-40 is an alternative standard to UL 1995. The UL Standard for Safety for Heating and Cooling Equipment, UL 1995 will be phased out by the year 2020, and will be replaced by UL 60335-2-40, the Standard for Safety for Household and Similar Electrical Appliances, Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers. UL 60335-2-40 is harmonized with requirements in Canada and Europe.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 076

UMC 2021  Section: 911.0 - 911.2.2, Table 1701.1

SUBMITTER: Maria Yepremian
County of Los Angeles Building and Safety

RECOMMENDATION:
Revise text

911.0 Decorative Appliances for Installation in Vented Fireplaces.

911.1 Prohibited Installations in Vented Fireplaces. Decorative appliances for installation in vented fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with Section 701.4. [NFPA 54:10.6.1]

911.2.1 Installation. A decorative appliance for installation in a vented fireplace shall be installed only in a vented fireplace having a working chimney flue and constructed of noncombustible materials. These appliances shall not be thermostatically controlled. [NFPA 54:10.6.2]

911.2.1.2 Listed Decorative Appliance. A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer’s installation instructions.

911.2.2 In Manufactured Homes. A decorative appliance for installation in a vented fireplace, where installed in a manufactured home, shall be listed for installation in manufactured homes. [NFPA 54:10.6.2.2]

911.2.2.1 Unlisted Decorative Appliance. An unlisted decorative appliance for installation in a vented fireplace shall be installed in a fireplace having a permanent free opening, based on appliance input rating and chimney height, equal to or greater than that specified in Table 911.2. [NFPA 54:10.6.2.3]

911.2.3 In Manufactured Homes. A decorative appliance for installation in a vented fireplace, where installed in a manufactured home, shall be listed for installation in manufactured homes. [NFPA 54:10.6.2.2]

911.2.3 Unlisted Decorative Appliance. An unlisted decorative appliance for installation in a vented fireplace shall be installed in a fireplace having a permanent free opening, based on appliance input rating and chimney height, equal to or greater than that specified in Table 911.2. [NFPA 54:10.6.2.3]

911.2.5 Fireplace Screens. A fireplace screen shall be installed with a decorative appliance for installation in a vented fireplace. [NFPA 54:10.6.3]

911.2.1 Alcohol Fuel Burning. Factory-built unvented liquid or gelled alcohol based intended to be fixed shall comply with UL 1370. No combustible material shall be within 18 inches (457 mm) of the appliance.

911.2.2 Prohibited Use. Factory-built unvented decorative appliances shall be used for decorative purposes and shall not be used as a primary heat source, a cooking appliance, or in conjunction with a blower assembly.

Unvented decorative appliances shall not be installed in spaces in which flammable vapors or gases may be present.

Unvented decorative appliances shall not be installed in bathrooms or bedrooms unless the appliance is listed for such purpose, and the bedroom or bathroom has the required volume of indoor air in accordance with Section 701.4.

### TABLE 1701.1

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1370-2011</td>
<td>Unvented Alcohol Fuel Burning Decorative Appliances (with revisions through March 25, 2016)</td>
<td>Unvented Appliances</td>
<td>911.2.1</td>
</tr>
</tbody>
</table>
Note: UL 1370 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
The existing code does not provide any information for unvented decorative appliances such as alcohol base space heaters. These systems are being installed more and more everyday and the UMC does not provide guidance as to what are the appropriate requirements for the safe installation for such systems. UL 1370 is the appropriate standards for such application. However, Section 911.2 will clarify that such systems shall be installed in accordance with the manufacturer’s installation instructions and its listing. This is necessary because there have been instances where the manufacturer’s installation instructions conflict the listing. In such case where the installation instructions conflict the listing, the more stringent provisions shall prevail in accordance with Section 102.1 of the UMC.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change raises grave safety concerns as to public health and safety.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
911.0 Decorative Appliances for Installation in Vented Fireplaces.

911.1 Prohibited Installations in Vented Fireplaces. Decorative appliances for installation in vented fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with Section 701.4. [NFPA 54:10.6.1]

911.2.1 Installation. A decorative appliance for installation in a vented fireplace shall be installed only in a vented fireplace having a working chimney flue and constructed of noncombustible materials. These appliances shall not be thermostatically controlled. [NFPA 54:10.6.2]

911.2.2 Listed Decorative Appliance. A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer’s installation instructions.

911.2.3 In Manufactured Homes. A decorative appliance for installation in a vented fireplace, where installed in a manufactured home, shall be listed for installation in manufactured homes. [NFPA 54:10.6.2.2]

911.2.4 Unlisted Decorative Appliance. An unlisted decorative appliance for installation in a vented fireplace shall be installed in a fireplace having a permanent free opening, based on appliance input rating and chimney height, equal to or greater than that specified in Table 911.2. [NFPA 54:10.6.2.3]

911.2.5 Fireplace Screens. A fireplace screen shall be installed with a decorative appliance for installation in a vented fireplace. [NFPA 54:10.6.3]

911.2 In Solid Fuel-Burning Fireplaces. Decorative gas appliances for installation in solid fuel-burning fireplace and having an input rating of not more than 400 000 Btu/hr (117 kW) shall comply with CSA Z21.60 and shall be installed in accordance with the manufacturer’s installation instructions. Manually lighted, natural gas decorative appliances shall comply with CSA Z21.84.

911.2.1 Natural Log. Decorative appliances used in a solid fuel-burning fireplace shall be comply with CSA Z21.60 and shall be installed in accordance with the manufacturer’s installation instructions.

911.2.2 Thermostatic Control. The decorative gas appliance shall not be thermostatically controlled.

911.2.3 Automatic Shutoff. The decorative gas appliance shall be provided with a flame safeguard device that will automatically shut off the gas supply to the main burner when the flame or ignition source is not provided.
<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA Z21.60-2017</td>
<td>Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces (same as CSA 2.26)</td>
<td>Decorative Gas Appliances</td>
<td>911.2, 911.2.1</td>
</tr>
</tbody>
</table>

Note: CSA Z21.60 and CSA Z21.84 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA Z21.60-2012</td>
<td>Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces (same as CSA 2.26)</td>
<td>Decorative Appliances, Decorative Fireplace Appliances</td>
</tr>
</tbody>
</table>

SUBSTANTIATION:
Section 911.0 has been revised to include standards for decorative appliances. The UMC currently does not have the minimum requirements for solid-fuel burning fireplaces and natural logs. Such requirements are needed for enforceable purposes.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed new language is already addressed in the current code language. Furthermore, the term "solid-fuel burning fireplaces" is not defined.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
SUBMITTER: David Dias  
Sheet Metal Workers Local 104

RECOMMENDATION:  
Revise text

920.0 Household Cooking Appliances.

920.4 Built-In Units. (remaining text unchanged)

920.4.2 Vertical Clearance. Built-in top (or surface) cooking appliances shall have a vertical clearance above the cooking top of not less than 30 inches (762 mm) to combustible material or metal cabinets. A clearance of not less than 24 inches (610 mm) is permitted where one of the following is installed:

1. The underside of the combustible material or metal cabinet above the cooking top is protected with not less than ¼ of an inch (6.4 mm) insulating millboard covered with sheet metal not less than 0.0122 of an inch (0.3099 mm) thick.
2. A metal ventilating hood of sheet metal not less than 0.0122 of an inch (0.3099 mm) thick is installed above the cooking top with a clearance of not less than ¼ of an inch (6.4 mm) between the hood and the underside of the combustible material or metal cabinet, and the hood not less than the width of the appliance and is centered over the appliance.
3. A listed cooking appliance or microwave oven installed over a listed cooking appliance shall be in accordance with the terms of the upper appliance listing and the manufacturer’s installation instructions. Microwave ovens shall comply with UL 923.

**TABLE 1701.1**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 923-2013</td>
<td>Microwave Cooking Appliances (with revisions through November 18, 2015)</td>
<td>Microwaves</td>
<td>920.3.2(3), 920.4.2(3)</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 923 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:  
It is necessary to indicate UL 923 for microwaves appliances as it addresses built-in units as well. It is currently addressed for floor-installed cooking appliances and it should also be installed in built-in units.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  
AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 079
UMC 2021  Section: 922.4

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

922.0 Open-Top Broiler Units.

922.4 Commercial Units. Commercial open-top broiler units shall be provided with ventilation in accordance with NFPA 96 Chapter 5, Part II. [NFPA 54:10.18.4]

SUBSTANTIATION:
It is not necessary to refer the end user to NFPA 96 as the UMC extracts the entire NFPA 96 in Chapter 5.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

922.0 Open-Top Broiler Units.

922.4 Commercial Units. Commercial open-top broiler units shall be provided with ventilation in accordance with Chapter 5, Part II. [NFPA 54:10.18.4]

COMMITTEE STATEMENT:
The proposed amendment retains the NFPA 54 extract reference as it meets the same intent.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 080
UMC 2021  Section: 934.1, Table 1701.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

934.0 Refrigeration Appliances.
934.1 Self-Contained Refrigerators and Freezers. Factory-built commercial refrigerators and freezers shall comply with UL 471 or UL 60335-2-89 and be installed in accordance with the manufacturer's installation instructions.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>934.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 60335-2-89 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
UL 60335-2-89 is an alternative standard to UL 412, UL 427, and UL 471. This standard is harmonized with requirements in Canada and Europe.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

934.0 Refrigeration Appliances.
934.1 Self-Contained Refrigerators and Freezers. Factory-built commercial refrigerators and freezers shall comply with UL 471 or UL 60335-2-89 and shall be installed in accordance with the manufacturer's installation instructions.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>934.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)
Note: UL 60335-2-89 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

COMMITTEE STATEMENT:
The term "shall" is being added to the last portion of the sentence in order to make the language enforceable.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
ITEM #: 081

UMC 2021 Section: 934.2, Table 1701.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

934.0 Refrigeration Appliances.

934.2 Unit Coolers. Factory-built unit coolers for use in refrigerators, freezers, refrigerated warehouses, and walk-in coolers shall comply with UL 412 or UL 60335-2-89 and be installed in accordance with the manufacturer's installation instructions.

TABLE 1701.1
REFERENCES 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 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>934.2</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 60335-2-89 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
UL 60335-2-89 is an alternative standard to UL 412, UL 427, and UL 471. This standard is harmonized with requirements in Canada and Europe.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

934.0 Refrigeration Appliances.

934.2 Unit Coolers. Factory-built unit coolers for use in refrigerators, freezers, refrigerated warehouses, and walk-in coolers shall comply with UL 412 or UL 60335-2-89 and shall be installed in accordance with the manufacturer's installation instructions.

TABLE 1701.1
REFERENCES 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 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>934.2</td>
</tr>
</tbody>
</table>
Note: UL 60335-2-89 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

COMMITTEE STATEMENT:
The term “shall” is being added to the last portion of the sentence in order to make the language enforceable.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Proposals

Edit Proposal

Item #: 082
UMC 2021  Section: 934.3, Table 1701.1

SUBMITTER: Christopher Jensen
UL LLC

RECOMMENDATION:
Revise text

934.0 Refrigeration Appliances.

934.3 Self-Contained Mechanical Refrigeration Systems. Self-contained mechanical refrigeration systems for use in walk-in coolers shall comply with UL 427 or UL 60335-2-89 and be installed in accordance with the manufacturer's installation instructions.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>934.3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: UL 60335-2-89 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
UL 60335-2-89 is an alternative standard to UL 412, UL 427, and UL 471. This standard is harmonized with requirements in Canada and Europe.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

934.0 Refrigeration Appliances.

934.3 Self-Contained Mechanical Refrigeration Systems. Self-contained mechanical refrigeration systems for use in walk-in coolers shall comply with UL 427 or UL 60335-2-89 and shall be installed in accordance with the manufacturer's installation instructions.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 60335-2-89-2017</td>
<td>Household and Similar Electrical Appliances – Safety – Part 2-89: Particular Requirements for Commercial Refrigerating Appliances with an Incorporated or Remote Refrigerant Unit or Compressor</td>
<td>Appliances</td>
<td>934.3</td>
</tr>
</tbody>
</table>
Note: UL 60335-2-89 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

COMMITTEE STATEMENT:
The term “shall” is being added to the last portion of the sentence in order to make the language enforceable.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 083

UMC 2021  Section: 223.0, 939.0 - 939.2, Table 1701.1

SUBMITTER: Bo Manalo
EcoSmart Inc.

RECOMMENDATION:
Revise text

939.0 Unvented Alcohol Fuel-Burning Decorative Appliances.

939.1 General. Unvented alcohol fuel burning decorative appliances shall be listed and labeled in accordance with UL1370 and shall be installed in accordance with the conditions of the listing and manufacturer’s installation instructions.

939.2 Marking. Unvented alcohol fuel-burning decorative appliances shall have a permanent factory-applied marking showing the manufacturer’s name, model, thermal output (BTU/hr)/(kW), approved fuel type, minimum room volume requirement for installation, and required clearances to combustibles.

CHAPTER 2
DEFINITIONS

223.0 – U –

Unvented Alcohol Fuel Burning Decorative Appliance. An unvented, self-contained fire feature appliance fueled by alcohol whose only function is providing an aesthetic effect of flames; intended to be directly or indirectly secured to the wall or floor and not for duct connection.

<table>
<thead>
<tr>
<th>TABLE 1701.1</th>
<th>REFERENCED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD NUMBER</td>
<td>STANDARD TITLE</td>
</tr>
<tr>
<td>UL 1370-2011</td>
<td>Unvented Alcohol Fuel Burning Decorative Appliances (with revisions through March 25, 2016)</td>
</tr>
</tbody>
</table>

Note: UL 1370 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
This proposal adds a provision for a newer type of decorative appliance. It provides clear and specific requirements for the installation of unvented, self-contained alcohol fuel burning appliances. The requisite ANSI consensus Standard UL1370 includes performance-based criteria that provide a consistent application of requirements and best practices to ensure safe installation and operation. The Standard includes combustion testing for carbon dioxide and carbon monoxide emission limits, oxygen depletion, materials and construction requirements. The Standard also tests for user abuse, stability, temperature, and wind tests. There is also a requirement for markings and instruction manual content. These appliances are intended for decorative purposes and not intended to be utilized as a primary heat source. Denatured alcohol is formulated for the application and limited to a maximum input rate of 0.25 gallons of fuel per hour (0.95 liters per hour). They are not provided with means for duct connection nor is there electric/mechanical assist of heated air movement, such as a fan-blower assembly. The appliances are also labeled with minimum room volume requirements for installation. The proposal improves the Code by providing installers and building officials with a clear path on the specifications that pertain to these products. Installation is intended to be in accordance with local codes, the manufacturer’s installation instructions and markings on the appliance.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change raises safety concerns as to public health and safety. If the AHJ would like to approve these appliances, they can do so by the Alternate Materials and Methods approval process in accordance with Section 302.2 of the UMC.
TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1

HOWARD

EXPLANATION OF NEGATIVE:

HYDE: As an enforcing agency, we are starting to see more and more of these types of appliances and nothing in any code regulates the installation of these types of appliances.
1001.0 General.

1001.7 Potable Water Protection. Potable water connections to steam or hot water boilers shall be protected from backflow by one of the following:
(1) Double check valve backflow prevention assembly compliant to ASSE 1015, AWWA C510, or CSA B64.5.
(2) Reduced pressure principle backflow prevention assembly compliant to ASSE 1013, AWWA C511, or CSA B64.4.
(3) Backflow preventer with intermediate atmospheric vent and pressure reducing valve compliant to ASSE 1081.
(4) Backflow preventer with intermediate atmospheric vent compliant to ASSE 1012. Where chemicals are introduced into the system, a reduced pressure principle backflow prevention assembly shall be provided in accordance with Section 1001.7(2).

TABLE 1701.1
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 1012-2009</td>
<td>Backflow Preventers with an Intermediate Atmospheric Vent</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
<tr>
<td>ASSE 1013-2011</td>
<td>Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers</td>
<td>Backflow Protection</td>
<td>1202.2, 1001.7</td>
</tr>
<tr>
<td>ASSE 1015-2011</td>
<td>Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
<tr>
<td>ASSE 1081-2014</td>
<td>Performance Requirements for Backflow Preventers with Integral Pressure Reducing Boiler Feed Valve and Intermediate Atmospheric Vent Style for Domestic and Light Commercial Water Distribution Systems</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
<tr>
<td>AWWA C510-2017</td>
<td>Double Check-Valve Backflow Prevention Assembly</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
<tr>
<td>AWWA C511-2007</td>
<td>Reduced-Pressure Principle Backflow Prevention Assembly</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
<tr>
<td>CSA B64.4-2011 (R2016)</td>
<td>Reduced Pressure Principle (RP) Backflow Preventers</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
<tr>
<td>CSA B64.5-2011 (R2016)</td>
<td>Double Check Valve (DCVA) Backflow Preventers</td>
<td>Backflow Protection</td>
<td>1001.7</td>
</tr>
</tbody>
</table>
Note: ASSE 1012, ASSE 1013, ASSE 1015, ASSE 1081, AWWA C510, AWWA C511, CSA B64.4, and CSA B64.5 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
There is no definition in the UMC of required protection of the potable water system from the water from within the boiler recirculating system. This water is non-potable as it generally contains pipe scale and is generally not exchanged but rather refilled if a portion of it is discharged from pressure relief valves after being heated. An ASSE 1081 device's primary function is to fill and reduce static boiler pressure under normal conditions, as well as to prevent backflow into potable water supply lines within a premises when pressure is temporarily higher in the closed boiler loop than in the potable water piping. Since the valves are boiler feed valves, they are not installed directly into the potable water pipeline and are not intended for use as potable water products.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is already addressed in Section 312.1 of the UMC which refers the user to the UPC for backflow prevention.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
**Item #: 085**  
UMC 2021  Section: TIA 002-18, Table 1102.3

**SUBMITTER:** April Trafton  
Donald Dickerson Associates

**RECOMMENDATION:**  
Revise text

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### TABLE 1102.3  
REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES  
[ASHRAE 34: TABLE 4-1, TABLE 4-2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA(^3)</th>
<th>CHEMICAL NAME(^1) (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP(^7)</th>
<th>OEL(^2) (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-500</td>
<td>azeotrope(^3)</td>
<td>R-12/152a(73.8/26.2)(^4)</td>
<td>A1</td>
<td>1000</td>
<td>7.6</td>
</tr>
<tr>
<td>R-501</td>
<td>azeotrope(^3)</td>
<td>R-22/12(75.0/25.0)</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-502</td>
<td>azeotrope(^3)</td>
<td>R-22/115(48.8/51.2)</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-503</td>
<td>azeotrope(^3)</td>
<td>R-23/13(40.1/59.9)</td>
<td>—</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>R-504</td>
<td>azeotrope(^3)</td>
<td>R-32/115(48.2/51.8)</td>
<td>—</td>
<td>1000</td>
<td>28</td>
</tr>
<tr>
<td>R-505</td>
<td>azeotrope(^3)</td>
<td>R-12/31 (78.0/22.0)(^4)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-506</td>
<td>azeotrope(^3)</td>
<td>R-31/114 (55.1/44.9)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-507A(^5)</td>
<td>azeotrope(^3)</td>
<td>R-125/143a(50.0/50.0)</td>
<td>A1</td>
<td>1000</td>
<td>32</td>
</tr>
<tr>
<td>R-508A(^5)</td>
<td>azeotrope(^3)</td>
<td>R-23/116(39.0/61.0)</td>
<td>A1</td>
<td>1000</td>
<td>14</td>
</tr>
<tr>
<td>R-508B</td>
<td>azeotrope(^3)</td>
<td>R-23/116(46.0/54.0)</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-509A(^5)</td>
<td>azeotrope(^3)</td>
<td>R-22/218(44.0/56.0)</td>
<td>A1</td>
<td>1000</td>
<td>24</td>
</tr>
<tr>
<td>R-510A</td>
<td>azeotrope(^3)</td>
<td>R-E170/600a(88.0/12.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.87</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>Azeotrope</td>
<td>R-290/E170(95.0/5.0)</td>
<td>A</td>
<td>1000</td>
<td>0.59</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>----------------------</td>
<td>---</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>R-511A</td>
<td>azo trope</td>
<td>R-134a/152a(5.0/95.0)</td>
<td>A2</td>
<td>1000</td>
<td>1.9</td>
</tr>
<tr>
<td>R-512A</td>
<td>azo trope</td>
<td>R-1234yf/134a (56.0/44.0)</td>
<td>A1</td>
<td>650</td>
<td>20</td>
</tr>
<tr>
<td>R-513A</td>
<td>azo trope</td>
<td>R-1234yf/134a (58.5/41.5)</td>
<td>A1</td>
<td>640</td>
<td>21</td>
</tr>
<tr>
<td>R-513B</td>
<td>azo trope</td>
<td>R-1336mzz(Z)/1130 (E) (74.7/25.3)</td>
<td>B1</td>
<td>320</td>
<td>0.86</td>
</tr>
<tr>
<td>R-514A</td>
<td>azo trope</td>
<td>R-1234zet(E)/227ea (88.0/12.0)</td>
<td>A1</td>
<td>810</td>
<td>19</td>
</tr>
<tr>
<td>R-515A</td>
<td>azo trope</td>
<td>R-1336mzz(Z)/1130 (E) (74.7/25.3)</td>
<td>B1</td>
<td>320</td>
<td>0.86</td>
</tr>
<tr>
<td>R-732</td>
<td>oxygen</td>
<td>oxygen</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

For SI units: 1 pound = 0.453 kg, 1 cubic foot = 0.0283 m³

Notes:
1. The preferred chemical name is followed by the popular name in parenthesis.
2. The OELs are 8-hour TWAs; a "C" designation denotes a ceiling limit.
3. Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated. The extent of segregation depends on the particular azeotrope and hardware system configuration.
4. The exact composition of this azeotrope is in question and additional experimental studies are needed.
5. R-507, R-508, and R-509 shall be permitted as alternative designations for R-507A, R-508A, and R-509A due to a change in designations after assignment of R-500 through R-509. Corresponding changes were not made for R-500 through R-506.
6. The RCL values for these refrigerant blends are approximated in the absence of adequate data for a component comprising less than 4 percent m/m of the blend and expected to have only a small influence in an acute, accidental release.
7. Refrigerant flammability classification of Class 2L shall comply with the requirements for flammability classification of Class 2.
8. In accordance with Section 1102.2, ammonia refrigeration systems are not regulated by this chapter. R-717 (ammonia) is included in this table because the table is extracted from ASHRAE 34 and is not capable of being modified.

(portions of table not shown remain unchanged)

SUBSTANTIATION:
Technical Merit: Azeotropes are “an azeotropic blend containing two or more refrigerants whose equilibrium vapor and liquid phase compositions are the same at a given pressure.” Azeotropes are designated in the 500 series of refrigerants. The current footnote “3” is specific to azeotropes and not the entire column (Chemical Formula). Furthermore, the modification updates the Table 1102.2 to include all refrigerants listed in Table 4-1 & 4-2 of ASHRAE 34-2016, latest edition. Emergency nature: The emergency nature of this proposed TIA is supported by Section 5-2(a) of the Regulations Governing Committee Projects, “The document contains an error or an omission that was overlooked during a regular revision process.” The current Uniform Mechanical Code contains “footnote 3” for the entire column (Chemical Formula) which can lead to confusion and may lead to an incorrect designation of a refrigerant. The modifications are based on ASHRAE 15-2016, latest edition, which is currently referenced for the 2018 edition of the UMC.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 086
UMC 2021  Section: 1102.2, Table 1701.1

SUBMITTER: Jeffrey Shapiro  
International Code Consultants  
Rep: IIAR

RECOMMENDATION:  
Revise text

1102.0 Refrigeration Systems.

1102.2 Ammonia Refrigeration Systems. Refrigeration systems using ammonia as the refrigerant shall comply with IIAR 2, IIAR 3, IIAR 4, and IIAR 5, and IIAR 6 and shall not be required to comply with this chapter.

TABLE 1701.1  
REFERENCED STANDARDS

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

Note: IIAR 6 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:  
IIAR 6 is a new standard for maintenance and inspection of closed-circuit ammonia refrigeration systems that is part of the suite of IIAR standards regulating ammonia refrigeration systems. Because this standard addresses system maintenance, which is part of the UMC scope in Section 101.2, it is important to have the standard referenced by the UMC to provide for proper compliance and enforcement of ammonia system regulations.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:  
The proposed standard is being rejected as it is a maintenance manual and is a draft standard that is not yet completed at the time of this monograph.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME(^1) (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP(^7)</th>
<th>OEL(^2) (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-407H</td>
<td>zeotrope</td>
<td>R-32/125/134a (32.5/15.0/52.5)</td>
<td>A1</td>
<td>1000</td>
<td>19</td>
</tr>
<tr>
<td>R-407I</td>
<td>zeotrope</td>
<td>R-32/125/124a (19.5/8.5/72.0)</td>
<td>A1</td>
<td>1000</td>
<td>16.0</td>
</tr>
<tr>
<td>R-459A</td>
<td>zeotrope</td>
<td>R-32/1234yf/1234ze(E) (68.1/26.0/6.0)</td>
<td>A2L</td>
<td>870</td>
<td>23</td>
</tr>
<tr>
<td>R-459B</td>
<td>zeotrope</td>
<td>R-32/1234yf/1234ze(E) (21.0/69.0/10.0)</td>
<td>A2L</td>
<td>640</td>
<td>30</td>
</tr>
<tr>
<td>R-460A</td>
<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (12.0/52.0/14.0/22.0)</td>
<td>A1</td>
<td>650</td>
<td>24</td>
</tr>
<tr>
<td>R-460B</td>
<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (28.0/25.0/20.0/27.0)</td>
<td>A1</td>
<td>950</td>
<td>25</td>
</tr>
<tr>
<td>R-460C</td>
<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (2.5/2.5/46.0/49.0)</td>
<td>A1</td>
<td>900</td>
<td>20.0</td>
</tr>
<tr>
<td>R-461A</td>
<td>zeotrope</td>
<td>R-125/143a/134a/227ea/600a (55.0/5.0/32.0/5.0/3.0)</td>
<td>A1</td>
<td>1000</td>
<td>17</td>
</tr>
<tr>
<td>R-462A</td>
<td>zeotrope</td>
<td>R-32/125/143a/134a/600 (9.0/42.0/2.0/44.0/3.0)</td>
<td>A2</td>
<td>1000</td>
<td>3.9</td>
</tr>
<tr>
<td>R-464A</td>
<td>zeotrope</td>
<td>R-32/125/1234ze(E)/227ea (27.0/27.0/40.0/6.0)</td>
<td>A1</td>
<td>930</td>
<td>27.0</td>
</tr>
<tr>
<td>R-465A</td>
<td>zeotrope</td>
<td>R-32/290/1234yf (21.0/7.9/71.1)</td>
<td>A2</td>
<td>660</td>
<td>2.5</td>
</tr>
<tr>
<td>R-516A</td>
<td>azeotrope(^3)</td>
<td>R-1234yf/134a/152a (77.5/8.5/14.0)</td>
<td>A2L</td>
<td>590</td>
<td>7.0</td>
</tr>
</tbody>
</table>
R-1132a  |  CF₂ = CH₂  |  1, 1-difluoroethylene  |  A₂  |  500  |  2.0  
R-1224yd(Z)  |  CF₃CF=CHCl  |  (Z)-1-chloro-2,3,3,3-tetrafluoropropen  |  A₁  |  1000  |  23  

(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
In accordance with IAPMO Governing Consensus Project, Table 1102.3 has been revised to correlate with Addendums ak, al, am, and an (published January 28, 2017), Addendum w (published on February 1, 2017), Addendums a, b, c and d (published June 23, 2017), Addendums f and c (published October 3, 2017); and Addendums j, k, l and m (published on January 20, 2018) of ASHRAE 34.

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

Amend proposal as follows:

**TABLE 1102.3**
**REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES**
[ASHRAE 34: TABLE 4-1, TABLE 4-2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME¹ (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP²</th>
<th>OEL² (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-407H</td>
<td>zeotrope</td>
<td>R-32/125/134a (32.5/15.0/52.5)</td>
<td>A₁</td>
<td>1000</td>
<td>19</td>
</tr>
<tr>
<td>R-407I</td>
<td>zeotrope</td>
<td>R-32/125/124a (19.5/8.5/72.0)</td>
<td>A₁</td>
<td>1000</td>
<td>16.0</td>
</tr>
<tr>
<td>R-459A</td>
<td>zeotrope</td>
<td>R-32/1234yf/1234ze(E) (68.1/26.0/6.0)</td>
<td>A₂L</td>
<td>870</td>
<td>23</td>
</tr>
<tr>
<td>R-459B</td>
<td>zeotrope</td>
<td>R-32/1234yf/1234ze(E) (21.0/69.0/10.0)</td>
<td>A₂L</td>
<td>640</td>
<td>30</td>
</tr>
<tr>
<td>R-460A</td>
<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (12.0/52.0/14.0/22.0)</td>
<td>A₁</td>
<td>650</td>
<td>24</td>
</tr>
<tr>
<td>R-460B</td>
<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (28.0/25.0/20.0/27.0)</td>
<td>A₁</td>
<td>950</td>
<td>25</td>
</tr>
<tr>
<td>R-460C</td>
<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (2.5/2.5/46.0/49.0)</td>
<td>A₁</td>
<td>900</td>
<td>20.0</td>
</tr>
<tr>
<td>R-461A</td>
<td>zeotrope</td>
<td>R-125/143a/134a/227ea/600a (55.0/5.0/32.0/5.0/3.0)</td>
<td>A₁</td>
<td>1000</td>
<td>17</td>
</tr>
<tr>
<td>R-462A</td>
<td>zeotrope</td>
<td>R-32/125/143a/134a/600 (9.0/42.0/2.0/44.0/3.0)</td>
<td>A₂</td>
<td>1000</td>
<td>3.9</td>
</tr>
<tr>
<td>R-463A</td>
<td>zeotrope</td>
<td>R-744/32/125/1234yf/134a (6.0/36.0/30.0/14.0/14.0)</td>
<td>A₁</td>
<td>990</td>
<td>19</td>
</tr>
<tr>
<td>R-464A</td>
<td>zeotrope</td>
<td>R-32/125/1234ze(E)/227ea (27.0/27.0/40.0/6.0)</td>
<td>A₁</td>
<td>930</td>
<td>27.0</td>
</tr>
<tr>
<td>R-465A</td>
<td>zeotrope</td>
<td>R-32/290/1234yf (21.0/7.9/71.1)</td>
<td>A₂</td>
<td>660</td>
<td>2.5</td>
</tr>
<tr>
<td>R-516A</td>
<td>azeotrope³</td>
<td>R-1234yf/134a/152a (77.5/8.5/14.0)</td>
<td>A₂L</td>
<td>590</td>
<td>7.0</td>
</tr>
<tr>
<td>R-1132a</td>
<td>CF₂ = CH₂</td>
<td>1, 1-difluoroethylene</td>
<td>A₂</td>
<td>500</td>
<td>2.0</td>
</tr>
<tr>
<td>R-1224yd(Z)</td>
<td>CF₃CF=CHCl</td>
<td>(Z)-1-chloro-2,3,3,3-</td>
<td>A₁</td>
<td>1000</td>
<td>23</td>
</tr>
</tbody>
</table>
COMMITTEE STATEMENT:
Refrigerant R-463A has been added to ASHRAE 34-2016 through addendum (i) and it is appropriate to include it in Table 1102.3 of the UMC.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
1103.3 Higher Flammability Refrigerants. Group A3 and B3 refrigerants shall not be used except where approved by the Authority Having Jurisdiction.

Exceptions:
(1) Laboratories with more than 100 square feet (9.29 m²) of space per person.
(2) Industrial occupancies.
(3) Listed portable unit self-contained systems containing not more than 0.331 pounds (0.150 kg) of Group A3 refrigerant, provided that the equipment is installed in accordance with the listing and the manufacturer’s installation instructions. [ASHRAE 15:7.5.3]

1104.0 Requirements for Refrigerant and Refrigeration System Use.

1104.4 Industrial Occupancies and Refrigerated Rooms. Section 1104.2 shall not apply in industrial occupancies and refrigerated rooms where in accordance with the following:
(1) The space(s) containing the machinery is (are) separated from other occupancies by tight construction with tight-fitting doors.
(2) Access is restricted to authorized personnel.
(3) The floor area per occupant is not less than 100 square feet (9.29 m²).
   Exception: The minimum floor area shall not apply where the space is provided with egress directly to the outdoors or into approved building exits.
(4) Refrigerant detectors are installed with the sensing location and alarm level as required in refrigeration machinery rooms in accordance with Section 1106.2.2.2.
(5) Open flames and surfaces exceeding 800°F (427°C) shall not be permitted where a Group A2, B2, A3, or B3 refrigerant, is used.
(6) Electrical equipment that is in accordance with Class 1, Division 2, of NFPA 70 where the quantity of a Group A2, B2, A3, or B3 refrigerant in an independent circuit is capable of exceeding 25 percent of the lower flammability limit (LFL) upon release to the space based on the volume determined in accordance with Section 1104.2.1 through Section 1104.2.3.
(7) Refrigerant containing parts in systems exceeding 100 horsepower (74.6 kW) compressor drive power, except evaporators used for refrigeration or dehumidification, condensers used for heating, control and pressure-relief valves for either, low-probability pumps, and connecting piping, are located in a machinery room or outdoors. [ASHRAE 15:7.2.2]

CHAPTER 2 DEFINITIONS

214.0 – L –

Low-Probability Pump. A pump that (a) is permanently sealed to prevent atmospheric release of the pumped fluid, (b) incorporates a static seal to prevent atmospheric release of the pumped fluid, or (c) incorporates not less than two sequential dynamic shaft seals and automatically shuts down upon failure of any seal to prevent atmospheric release of the pumped fluid. [ASHRAE 15:3]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Section 1103.3 and Section 1104.4 are being revised, and a definition for Low-Probability Pump is being added to Chapter 2 to correlate with Addenda b of ASHRAE 15 which was published on June 29, 2017.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
<table>
<thead>
<tr>
<th>TOTAL ELIGIBLE TO VOTE:</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOTING RESULTS:</td>
<td></td>
</tr>
<tr>
<td>AFFIRMATIVE:</td>
<td>25</td>
</tr>
<tr>
<td>NOT RETURNED:</td>
<td>1 HOWARD</td>
</tr>
</tbody>
</table>
TABLE 1104.1
PERMISSIBLE REFRIGERATION SYSTEMS

<table>
<thead>
<tr>
<th>OCCUPANCY GROUP³</th>
<th>HIGH-PROBABILITY SYSTEM</th>
<th>LOW PROBABILITY SYSTEM</th>
<th>MACHINERY ROOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>A-2</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>A-3</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>A-4</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>B</td>
<td>Group A1² or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>E</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>F-1</td>
<td>Group A1² or A2L only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>F-2</td>
<td>Any²</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-1</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-2</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-3</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-4</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-5</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-1</td>
<td>None</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-2</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-3</td>
<td>None</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-4</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>M</td>
<td>Group A1² or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>R-1</td>
<td>Group A1 or A2L⁴ only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group A1 or A2L (^4) only</td>
<td>Any</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>-------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>R-2</td>
<td></td>
<td>Group A1 or A2L (^4) only</td>
<td>Any</td>
</tr>
<tr>
<td>R-3</td>
<td></td>
<td>Group A1 or A2L (^4) only</td>
<td>Any</td>
</tr>
<tr>
<td>R-4</td>
<td></td>
<td>Group A1 or A2L (^4) only</td>
<td>Any</td>
</tr>
<tr>
<td>S-1</td>
<td></td>
<td>Group A1(^2) or A2L (^4) only</td>
<td>Any</td>
</tr>
<tr>
<td>S-2</td>
<td></td>
<td>Any(^2)</td>
<td>Any</td>
</tr>
<tr>
<td>U</td>
<td></td>
<td>Any</td>
<td>Any</td>
</tr>
</tbody>
</table>

Notes:

1. See Section 1104.0.
2. A refrigerant shall be permitted to be used within a high-probability system where the room or space is in accordance with Section 1104.4.
3. Occupancy classifications are defined in the building code.
4. See Section 1104.6 for requirements applicable to A2L equipment.

SUBSTANTIATION:
This change clarifies the acceptance of Group A2L refrigerants in high probability systems used for human comfort. Section 1104.6 already permits Group A2L refrigerants to be used for human comfort in direct systems provided the equipment is listed for A2L refrigerants. Note 4 identifies the requirements in Section 1104.6 for A2L refrigerants. This will assure that the equipment meets the listing and safety requirements of Section 1104.6.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is being rejected based on the action taken on Item # 091.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 ABSTAIN: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF ABSTAIN:
KOERBER: Warrants further review of Item # 089 and Item # 091.
1104.0 Requirements for Refrigerant and Refrigeration System Use.

1104.2.3 Ventilated Spaces. Where a refrigerating system or a part thereof is located within an air handler, in an air distribution duct system, or in an occupied space served by a mechanical ventilation system, the entire air distribution system shall be analyzed to determine the worst-case distribution of leaked refrigerant. The worst case or the smallest volume in which the leaked refrigerant disperses shall be used to determine the refrigerant quantity limit in the system, subject to the criteria in accordance with Section 1104.2.3.1 through Section 1104.2.3.3. [ASHRAE 15:7.3.2]

1104.2.3.1 Closures. Closures in the air distribution system shall be considered. Where one or more spaces of several arranged in parallel are capable of being closed off from the source of the refrigerant leak, their volume(s) shall not be used in the calculation.

Exceptions: The following closure devices shall not be considered:
- (1) Smoke dampers, fire dampers, and combination smoke and fire dampers that close only in an emergency not associated with a refrigerant leak.
- (2) Dampers, such as variable-air-volume (VAV) boxes, that provide limited closure where airflow is not reduced below 10 percent of its maximum (with the fan running). [ASHRAE 15:7.3.2.1]

1104.2.3.2 Plenums. The space above a suspended ceiling shall not be included in calculating the refrigerant quantity limit in the system limits unless such space is part of the air supply or return system. [ASHRAE 15:7.3.2.2]

1104.2.3.3 Supply and Return Ducts. The volume of the supply and return ducts and plenums shall be included when calculating the refrigerant quantity limit in the system. [ASHRAE 15:7.3.2.3]

1104.7.1 Recovered Refrigerants. Recovered refrigerants shall not be reused except in the system from which they were removed or as provided in Section 1104.7.2 or Section 1104.7.3. Where contamination is evident by discoloration, odor, acid test results, or system history, recovered refrigerants shall be reclaimed in accordance with Section 1104.7.3 before reuse. [ASHRAE 15:7.5.1.4]

1105.0 General Requirements.

1105.12.1 Quantity. The total amount of refrigerant stored in a machinery room in all containers not provided with relief valves and piping in accordance with Section 1113.0 shall not exceed 330 pounds (149.7 kg). Refrigerant shall be stored in approved storage containers. Additional quantities of refrigerant shall be stored in an approved storage facility. [ASHRAE 15:11.5]

1109.0 Refrigeration Piping, Containers, and Valves.

1109.1 Materials. Materials used in the construction and installation of refrigerating systems shall be suitable for compatible with the conveying refrigerant used. Materials shall not be used that will deteriorate due to the chemical action because of the refrigerant, lubricant, or their combination of both where exposed to in presence of air or moisture to a degree that poses a safety hazard. [ASHRAE 15:9.1.1] Refrigerant piping shall be metallic.
1112.0 Pressure-Relief Devices.

1112.12.5 Simultaneous Operation. Where outlets of two or more relief devices or fusible plugs, which are expected to operate simultaneously, connect to a common discharge pipe, the common pipe shall be sized large enough to prevent the outlet back pressure at each relief device from exceeding the maximum allowable outlet back pressure in accordance with Section 1112.12.4. [ASHRAE 15:9.7.9.3.3]

1113.0 Overpressure Protection.

1113.1 General. Pressure vessels shall be provided with overpressure protection in accordance with ASME BPVC Section VIII. Pressure vessels containing liquid refrigerant that are capable of being isolated by stop valves from other parts of the a refrigerating system shall be provided with overpressure protection. Pressure-relief devices or fusible plugs shall be sized in accordance with Section 1113.5. [ASHRAE 15:9.7.1, 9.7.2]

1113.2 Type of Protection. Pressure vessels with an internal gross volume of 3 cubic feet (0.1 m$^3$) or less shall use one or more pressure-relief devices or a fusible plug. Pressure vessels of more than 3 cubic feet (0.1 m$^3$) but less than 10 cubic feet (0.28 m$^3$) internal gross volume shall use one or more pressure-relief devices; fusible plugs shall not be used. [ASHRAE 15:9.7.2.1, 9.7.2.2]

1115.0 Labeling and Identification.

1115.4 Marking of Pressure-Relief Devices. Pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or an assembler as defined in accordance with ASME BPVC Section VIII. Each pressure relief valve shall be marked by the manufacturer or assembler with the data required in accordance with ASME BPVC Section VIII. Exception: Relief valves for systems with design pressures of 15 pounds-force per square inch gauge (psig) (103 kPa) or less shall be marked by the manufacturer with the pressure-setting capacity. [ASHRAE 15:9.6.1]

1117.0 Refrigerant-Containing Pressure Vessels.

1117.1 Inside Dimensions 6 inches or Less. Pressure vessels having inside dimensions of 6 inches (152 mm) or less shall comply with the following: be
(1) Listed either individually or as part of an assembly by an approved, nationally recognized testing laboratory, or,
(2) Marked directly on the vessel or on a nameplate attached to the vessel with a “U” or “UM” symbol signifying compliance in accordance with ASME BPVC Section VIII,
(3) Where requested by the Authority Having Jurisdiction, the manufacturer shall provide documentation to confirm that the vessel meets the design, fabrication, and testing requirements are in accordance with of ASME BPVC Section VIII.
Exception: Vessels having an internal or external design pressure of 15 psig (103 kPa) or less. Pressure vessels having inside dimensions of 6 inches (152 mm) or less shall be protected by either a pressure-relief device or a fusible plug. [ASHRAE 15:9.3.1.1]

1117.2 Inside Dimensions More than 6 inches. Pressure vessels having an inside diameter exceeding 6 inches (152 mm) and having an internal or external design pressure of more greater than 15 psig (103 kPa) shall be directly marked, or marked on a nameplate in accordance, with a “U” or “UM” symbol signifying compliance with the rules of ASME BPVC Section VIII. [ASHRAE 15:9.3.2]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Chapter 11 has been revised to correlate with the latest ASHRAE 15-2016.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
1104.6 Applications for Human Comfort and for Nonindustrial Occupancies. In nonindustrial occupancies, Group A2, A3, B1, B2L, B2, and B3 refrigerants shall not be used in high-probability systems for human comfort. Systems using Group A2L refrigerant in high-probability systems for human comfort shall comply with Section 1104.6.1 through Section 1104.6.3.

1104.6.1 A2L Refrigerant Equipment. The refrigeration equipment using A2L refrigerant shall be listed and comply with Section 903.1. The equipment shall be installed in accordance with the manufacturer's instructions. The nameplate shall include a flammable refrigerant symbol. A label indicating that a flammable refrigerant is used shall be placed adjacent to service ports and other locations where service involving components containing refrigerant is performed.

1104.6.2 Refrigerant Detection System. A refrigerant detection system shall be provided in accordance with Section 1104.6.4 where one or more of the following conditions are met:

1. Where the refrigerant charge of any independent circuit exceeds 22 pounds (10 kg) for commercial, public assembly and large mercantile occupancies.
2. Where the refrigerant charge of any independent circuit exceeds 6.6 pounds (3 kg) for residential and institutional occupancies.
3. Where using the provisions of Section 1104.6.3.
4. Where a refrigerant detection system is required by the equipment listing.

1104.6.2.1 Refrigerant Detection System Performance. Refrigerant detection systems shall comply with the following:

1. The refrigerant detection system set point to activate the functions in accordance with Section 1106.2.2.1 and Section 1106.2.2.2 shall be at a value not exceeding the RCL value specified in Table 1102.3 or 25 percent of the lower flammable limit (LFL) of the refrigerant.
2. One or more refrigerant detection systems shall be located such that refrigerant will be detected if the refrigerating system is operating or not operating. For refrigerating systems that are connected to the occupied space through a duct system, the refrigerant detection system shall be located in the listed equipment. For refrigerating systems that are directly connected to the occupied space without ducts, the refrigerant detection system shall be located in the equipment or in the occupied space at a height of not more than 12 inches (305 mm) above the floor within a horizontal distance of not more than 3.3 feet (1007 mm) with a direct line of sight of the unit.
3. The refrigerant detection system, including any sampling tubes, shall cause the functions required by Section 1104.6.2.2 within 10 seconds, after sensing the refrigerant concentration identified.
4. The refrigerant detection system shall provide a means for automatic operational self-test as required by the equipment listing. If a failure of the refrigerant detection system is identified, a trouble alarm shall be activated, and requirements of Section 1104.6.2.2 shall be initiated.
5. The refrigerant detection system shall be tested during installation to verify the alarm set point and response time as required in Section 1104.6.2.1(1) and Section 1104.6.2.1(3). After installation, the refrigerant detection system shall be tested annually or at an interval not exceeding the manufacturer's installation instructions, whichever is less to verify the alarm set point and response time.

1104.6.2.2 Refrigerant Detection System Activation. When the refrigerant detection system senses a refrigerant concentration above the RCL value specified in Table 1102.3, all of the following shall occur:

1. A minimum flow rate of supply air shall be provided in accordance with Equation 1104.6.2.2:

\[ Q = \frac{1001 \times M}{LFL} \]  

Where:

- \( Q \) is the supply air flow rate, cubic foot per minute (ft³/min).
$M$ is the refrigerant charge, pounds (lb).
$LFL$ is the lower flammability limit, pounds per 1000 cubic foot (lb/1000 ft$^3$).

For SI units: $Q = 60000 \times M / LFL$, where $Q$ is the supply air flow rate (m$^3$/h), $M$ is the refrigerant charge (kg), $LFL$ is the lower flammability limit (g/m$^3$).

(2) The compressor and all other electrical devices shall de-energize, excluding the control power transformers, control systems, and the supply air fan. The supply air fan shall continue to operate for a minimum of 5 minutes after the refrigerant detection system activates the fan.

(3) Devices that control airflow located within the equipment or in the duct system that supplies air to the occupied space shall be fully opened.

(4) Heaters and electrical devices located in the ductwork shall be de-energized.

1104.6.3 Ignition Source Prohibited. Open flame-producing devices shall not be permanently installed in the duct system for the space served by A2L refrigeration equipment. Continuously operating hot surfaces exceeding 1292°F (700°C) shall not be located within the duct system.

SUBSTANTIATION:
An error during the last cycle resulted in the allowance of Group B2L refrigerants for high probability systems for human comfort. Toxic refrigerants have never been permitted for high probability systems. The addition of B2L to the list of prohibited refrigerants corrects this error. While Section 1104.6 allows the use of Group A2L refrigerants in high probability systems for human comfort, the additional safety requirements in ASHRAE 15 and UL/CSA 60335-2-40 draft of the 3rd edition are not included. The last sentence of Section 1104.6 will require conformance with the safety requirements of Section 1104.6.1 through Section 1104.6.3 for equipment using A2L refrigerants. These safety requirements are consistent with ASHRAE 15, Addendum d (draft). The requirements identify when a refrigeration detection system is required and what the system must activate.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

1104.0 Requirements for Refrigerant and Refrigeration System Use.

1104.6 Applications for Human Comfort and for Nonindustrial Occupancies. In nonindustrial occupancies, Group A2, A2L, A3, B1, B2L, B2, and B3 refrigerants shall not be used in high-probability systems for human comfort. Systems using Group A2L refrigerant in high-probability systems for human comfort shall comply with Section 1104.6.1 through Section 1104.6.3.

1104.6.1 A2L Refrigerant Equipment. The refrigeration equipment using A2L refrigerant shall be listed and comply with Section 903.1. The equipment shall be installed in accordance with the manufacturer's instructions. The nameplate shall include a flammable refrigerant symbol. A label indicating that a flammable refrigerant is used shall be placed adjacent to service ports and other locations where service involving components containing refrigerant is performed.

1104.6.2 Refrigerant Detection System. A refrigerant detection system shall be provided in accordance with Section 1104.6.4 where one or more of the following conditions are met:

(1) Where the refrigerant charge of any independent circuit exceeds 22 pounds (10 kg) for commercial, public assembly and large mercantile occupancies.

(2) Where the refrigerant charge of any independent circuit exceeds 6.6 pounds (3 kg) for residential and institutional occupancies.

(3) Where using the provisions of Section 1104.6.3.

(4) Where a refrigerant detection system is required by the equipment listing.

1104.6.2.1 Refrigerant Detection System Performance. Refrigerant detection systems shall comply with the following:

(1) The refrigerant detection system set point to activate the functions in accordance with Section 1106.2.2.1 and Section 1106.2.2.2 shall be at a value not exceeding the RCL value specified in Table 1102.3 or 25 percent of the lower flammability limit (LFL) of the refrigerant.

(2) One or more refrigerant detection systems shall be located such that refrigerant will be detected if the refrigerating system is operating or not operating. For refrigerating systems that are connected to the occupied space through a duct system, the refrigerant detection system shall be located within the listed equipment. For refrigerating systems that are directly connected to the occupied space without ducts, the refrigerant detection system shall be located in the equipment or in the occupied space at a height of not more than 12 inches (305 mm) above the floor within a horizontal distance of not more than 3.3 feet (1007 mm) with a direct line of sight of the unit.

(3) The refrigerant detection system, including any sampling tubes, shall cause the functions required by Section 1104.6.2.2 within 10 seconds, after sensing the refrigerant concentration identified.

(4) The refrigerant detection system shall provide a means for automatic operational self-test as required by the equipment listing. If a failure of the refrigerant detection system is identified, a trouble alarm shall be activated, and requirements of Section 1104.6.2.2 shall be initiated.

(5) The refrigerant detection system shall be tested during installation to verify the alarm set point and response time as required in Section 1104.6.2.1(1) and Section 1106.2.1(3). After installation, the refrigerant detection system shall be tested annually or at an interval not exceeding the manufacturer's installation instructions, whichever is less to verify the alarm set point and response time.

1104.6.2.2 Refrigerant Detection System Activation. When the refrigerant detection system senses a refrigerant concentration above the RCL value specified in Table 1102.3, all of the following shall occur:

(1) A minimum flow rate of supply air shall be provided in accordance with Equation 1104.6.2.2.
\[ Q = \frac{1001 \times M}{LFL} \]  

[Equation 1104.6.2.2]

Where:
- \( Q \) is the supply air flow rate, cubic foot per minute (ft³/min).
- \( M \) is the refrigerant charge, pounds (lb).
- \( LFL \) is the lower flammability limit, pounds per 1000 cubic foot (lb/1000 ft³).

For SI units: \( Q = \frac{60000 \times M}{LFL} \), where \( Q \) is the supply air flow rate (m³/h), \( M \) is the refrigerant charge (kg), \( LFL \) is the lower flammability limit (g/m³).

(2) The compressor and all other electrical devices shall de-energize, excluding the control power transformers, control systems, and the supply air fan. The supply air fan shall continue to operate for a minimum of 5 minutes after the refrigerant detection system activates the fan.

(3) Devices that controls air flow located within the equipment or in the duct system that supplies air to the occupied space shall be fully opened.

(4) Heaters and electrical devices located in the ductwork shall be de-energized.

1104.6.3 Ignition Source Prohibited. Open flame-producing devices shall not be permanently installed in the duct system for the space served by A2L refrigeration equipment. Continuously operating hot surfaces exceeding 1292°F (700°C) shall not be located within the duct system.

COMMITTEE STATEMENT:
The proposed text is being modified as ASHRAE 15 Addendum d was still under public review and not yet finalized at the time that this monograph was published.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:

KOERBER: I believe the entire proposal needs further consideration without modification.
Proposals

Edit Proposal

Item #: 092

UMC 2021 Section: 1105.1, Table 1701.1, Table 1701.2

SUBMITTER: David C. Bixby
Air Conditioning Contractors of America

RECOMMENDATION:
Revise text

1105.0 General Requirements.
1105.1 Human Comfort. Cooling systems used for human comfort shall be in accordance with the return-air and outside-air provisions for furnaces in Section 904.7 and Section 904.8. Cooling equipment used for human comfort in dwelling units shall be selected in accordance with ACCA Manual S to satisfy the calculated loads determined in accordance with the reference standards in Chapter 17 ACCA Manual J or other approved methods. Refrigerants used for human comfort shall be in accordance with Section 1104.6.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI/ACCA Manual J-2016</td>
<td>Residential Load Calculations</td>
<td>Ducts</td>
<td>1105.1</td>
</tr>
<tr>
<td>ANSI/ACCA Manual S-2014</td>
<td>Residential Equipment Selection</td>
<td>Equipment</td>
<td>1105.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ACCA Manual J and ACCA Manual S meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCA Manual J 2016</td>
<td>Residential Load Calculations</td>
<td>Ducts</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The 2018 UMC mandates the use of ACCA Manual D (Residential Duct Systems) in Section 601.2 for duct sizing. However, mandating the use of only Manual D without using Manual J and Manual S will result in an incomplete design and installation as it will not account for calculating heating/cooling loads (Manual J) which is critical for duct sizing. In addition, Manual S needs to be used as it covers the design, sizing and selection of heating/cooling equipment based on use of Manuals D and J. Moreover, by not having the UMC mandate the use of Manuals S and J, the safety and performance of the HVAC system could be adversely affected and potentially impact the health and safety of the occupants. One concern is related to the potential for undersizing or oversizing HVAC equipment if these Manuals are not required. Such a condition could create excessive humidity levels in a home which in turn allows for the formation of mold with its potential associated health effects. Like ACCA Manual D, ACCA Manuals J and S also include a Normative code-enforceable section and are both ANSI standards that meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Projects. The addition of ACCA Manual J to Table 1701.1 is needed to support its proposed reference as a new requirement under 1105.1. Manual J includes a Normative code-enforceable section and is an ANSI standard that meets the...
requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Projects. The addition of ACCA Manual S to Table 1701.1 is needed to (1) support its current reference in Appendix E 607.2(3), and (2) support its proposed reference as a new requirement under 1105.1. Manual S includes a Normative code-enforceable section and is an ANSI standard that meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Projects.

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

Amend proposal as follows:

**1105.0 General Requirements.**

**1105.1 Human Comfort.** Cooling systems used for human comfort shall be in accordance with the return-air and outside-air provisions for furnaces in Section 904.7 and Section 904.8. Cooling equipment used for human comfort in *dwelling units-residential buildings* shall be selected in accordance with ACCA Manual S to satisfy the calculated loads determined in accordance with ACCA Manual J or other approved methods. Refrigerants used for human comfort shall be in accordance with Section 1104.6.

**TABLE 1701.1 REFERENCED STANDARDS**

<table>
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<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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</tr>
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<td>Residential Equipment Selection</td>
<td>Equipment</td>
<td>1105.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**COMMITTEE STATEMENT:**
The modification further clarifies the intent of code in regards to the section applying to "residential buildings" as the standards referenced only apply to residential occupancies.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
1105.4 Illumination and Service Receptacles. In addition to the requirements of Section 301.4, permanent lighting fixtures shall be installed for equipment required by this code to be accessible or readily accessible. Such fixtures shall provide illumination to perform the required tasks for which access is provided. Control of the illumination source shall be provided at the access entrance.

Exception:
(1) Lighting fixtures shall be permitted to be omitted where the fixed lighting of the building will provide the required illumination.
(2) Equipment located on the roof or on the exterior walls of a building.

SUBSTANTIATION:
The requirements for a lighting outlet to illuminate appliances installed in attics, underfloor spaces, utility rooms and basement are adequately covered in NFPA 70 Sections 210.70(A)(3) and 210.70(C). The requirements found in NFPA 70 cover all equipment that requires serving not just refrigeration equipment. There are conflicts with some of the terms used in this section and the corresponding requirements found in NFPA 70. The term “Lighting Fixture” has been replaced in the 2002 edition of NFPA 70 to the term “Luminaire” which is used internationally for lighting products. By removing specific electrical requirements from this code and leaving them in NFPA 70 it guarantees that there will be no conflicts between the codes.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The current language should remain in the code in order to give direction to the installer and to the AHJ.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 094
UMC 2021  Section: 1107.1.4

SUBMITTER: Connor Barbaree
ASHRAE

RECOMMENDATION:
Delete text without substitution

1107.0 Machinery Room, Special Requirements.
1107.1 General. (remaining text unchanged)

1107.1.4 Machinery Rooms. The refrigeration machinery room shall have a door that opens directly to the outdoors or through a vestibule equipped with self-closing, tightfitting doors.

(renumber remaining sections)

SUBSTANTIATION:
Section 1107.1.4 is being deleted to be consistent with industry standards. Furthermore, ASHRAE 15 also published Addenda F where the same provision was removed.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion is being rejected because the text is needed for enforcement of the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

P. TRAFTON: ASHRAE standards has elected this requirement and it's the prior standard for refrigeration rooms.
Item #: 095

UMC 2021  Section: 1108.1

SUBMITTER: Jeremy Martinez
   Golden Gate Chapter ASHRAE
   Rep: ASHRAE

RECOMMENDATION:
Revise text

1108.0 Refrigeration Machinery Room Equipment and Controls.
1108.1 General. Equipment, piping, ducts, vents, or similar devices that are not essential for the refrigeration process, maintenance of the equipment, or for the illumination, ventilation, or fire protection of the room require maintenance by personnel not authorized to access the refrigeration machinery room per Section 1106.11 shall not be placed in or pass through a refrigeration machinery room.

SUBSTANTIATION:
Equipment, piping, etc. that are routine parts of HVAC systems do not pose a safety risk unless unauthorized personnel are required to maintain them. Note that ASHRAE Standard 15 does not limit other HVAC equipment from being in a refrigeration machinery room, but does limit access to the room to authorized personnel so this change is consistent with ASHRAE Standard 15.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is not enforceable.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

P. TRRAFTON: The requirements should also follow ASHRAE 15.
Proposals

Item #: 096

UMC 2021  Section: 1109.0 - 1116.8, Table 1701.1

SUBMITTER:  Julius Ballanco, P.E.
JB Engineering and Code Consulting, P.C.
Rep: Daikin US

RECOMMENDATION:
Revise text

1109.0 Refrigeration Piping, Containers, and Valves.

1109.1 Materials. Materials used in the construction and installation of refrigerating systems shall be compatible with the conveying refrigerant used. Materials shall not be used that will deteriorate due to the chemical action of the refrigerant, lubricant, or combination of both where exposed to air or moisture to a degree that poses a safety hazard. [ASHRAE 15:9.1.1] Refrigerant piping shall be metallic.

1109.1.1 Copper and Copper Alloy Pipe. Copper and copper alloy refrigeration piping, valves, fittings, and related parts used in the construction and installation of refrigeration systems shall be approved for the intended use. Refrigeration piping shall comply with ASME B31.5.

1109.1.2 Copper Linesets. Copper linesets shall comply with ASTM B280 or ASTM B1003.

1109.1.3 Iron and Steel. Iron and steel refrigeration piping, valves, fittings, and related parts shall be approved for the intended use. Pipe exceeding 2 inches (50 mm) iron pipe size shall be electric resistance welded or seamless pipe. Refrigeration piping shall comply with ASME B31.5.

1109.1.4 Prohibited Contact. Aluminum, zinc, magnesium, or their alloys shall not be used in contact with methyl chloride. Magnesium alloys shall not be used where in contact with halogenated refrigerants. [ASHRAE 15:9.1.2]

1109.2 Joints. Iron or steel pipe joints shall be of approved threaded, flanged, or welded types. Exposed threads shall be tinned or coated with an approved corrosion inhibitor. Copper or copper alloy pipe joints of iron pipe size shall be of approved threaded, flanged, press-connect or brazed types. Copper tubing joints and connections shall be connected by approved flared, lapped, swaged, or brazed joints, soldered joints, or mechanical joints that comply with UL 207 either individually or as part of an assembly or a system by an approved nationally recognized laboratory. Piping and tubing shall be installed so as to prevent vibration and strains at joints and connections.

1109.3 Penetration of Piping. Refrigerant piping shall not penetrate floors, ceilings, or roofs.

Exceptions:

(1) Penetrations connecting the basement and the first floor.
(2) Penetrations connecting the top floor and a machinery penthouse or roof installation.
(3) Penetrations connecting adjacent floors served by the refrigeration system.
(4) Penetrations of a direct system where the refrigerant concentration does not exceed that listed in Table 1102.3 for the smallest occupied space through which the refrigerant piping passes.
(5) In other than industrial occupancies and where the refrigerant concentration exceeds that listed in Table 1102.3 for the smallest occupied space, penetrations that connect separate pieces of equipment that are in accordance with one of the following:
   (a) Enclosed by an approved gastight, fire-resistive duct or shaft with openings to those floors served by the refrigerating system.
   (b) Located on the exterior wall of a building where vented to the outdoors or to the space served by the system and not used as an air shaft, closed court, or similar space. [ASHRAE 15:8.10.3]

1109.4 Location of Refrigeration Piping. Refrigerant piping crossing an open space that affords passageway in a building shall be not less than 7.25 feet (2210 mm) above the floor unless the piping is located against the ceiling of such space and is permitted by the Authority Having Jurisdiction. [ASHRAE 15:8.10.1]

1109.4.1 Protection from Mechanical Damage. Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be located in an elevator, dumbwaiter, or other shaft containing a moving object, or in a shaft that has openings to living quarters, or to means of egress. Refrigerant piping shall not be installed in an enclosed public stairway, stair landing, or means of egress. [ASHRAE 15:8.10.2]
1109.5 Underground Piping. Refrigerant piping placed underground shall be protected against corrosion.

1109.5.1 Piping in Concrete Floors. Refrigerant piping installed in concrete floors shall be encased in a pipe duct.

Refrigerant piping shall be isolated and supported to prevent damaging vibration, stress, or corrosion. [ASHRAE 15:8.10.4]

1109.6 Support. In addition to the requirements of Section 1105.2, piping and tubing shall be securely fastened to a permanent support within 6 feet (1829 mm) following the first bend in such tubing from the compressor and within 2 feet (610 mm) of each subsequent bend or angle. Piping and tubing shall be supported at points not more than 15 feet (4572 mm) apart.

1109.7 Pipe Enclosure. Refrigerant piping and tubing shall be installed so that it is not subject to damage from an external source. Soft annealed copper tubing shall not exceed \( \frac{5}{8} \) inches (35 mm) nominal size. Mechanical joints, other than approved press-connect joints, shall not be made on tubing exceeding \( \frac{3}{4} \) of an inch (20 mm) nominal size. Soft annealed copper tubing conveying refrigerant shall be enclosed in iron or steel piping and fittings, or in conduit, molding, or raceway that will protect the tubing against mechanical injury from an external source.

Exceptions:
1. Tubing entirely within or tubing within 5 feet (1524 mm) of a refrigerant compressor where so located that it is not subject to external injury.
2. Copper tubing serving a dwelling unit, where such tubing contains Group A1 refrigerant and is placed in locations not subject to damage from an external source.

1109.8 Visual Inspection. Refrigerant piping and joints erected on the premises shall be exposed to view for visual inspection prior to being covered or enclosed.

Exception: Copper tubing enclosed in iron or steel piping conduit, molding, or raceway, provided there are no fittings or joints concealed therein.

1109.9 Condensation. Piping and fittings that convey brine, refrigerant, or coolants that during normal operation are capable of reaching a surface temperature below the dew point of the surrounding air and that are located in spaces or areas where condensation will cause a hazard to the building occupants or damage to the structure, electrical or other equipment shall be protected to prevent such damage.

1109.10 Identification. Piping shall be in accordance with the reference standard for identification. The type of refrigerant, function and pressure shall be indicated.

1110.0 Valves.

1110.1 More than 6.6 Pounds of Refrigerant. Systems containing more than 6.6 pounds (2.99 kg) of refrigerant shall have stop valves installed at the following locations:
1. The suction inlet of a compressor, compressor unit, or condensing unit.
2. The discharge of a compressor, compressor unit, or condensing unit.
3. The outlet of a liquid receiver.

Exceptions:
1. Systems that have a refrigerant pumpout function capable of storing the refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant.

1110.2 More than 110 Pounds of Refrigerant. Systems containing more than 110 pounds (49.9 kg) of refrigerant shall have stop valves installed at the following locations:
1. The suction inlet of a compressor, compressor unit, or condensing unit.
2. The discharge outlet of a compressor, compressor unit, or condensing unit.
3. The inlet of a liquid receiver, except for self-contained systems or where the receiver is an integral part of the condenser or condensing unit.
4. The outlet of a liquid receiver.
5. The inlets and outlets of condensers where more than one condenser is used in parallel in the system.

Exception: Systems that have a refrigerant pumpout function capable of storing the refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant or self-contained systems. [ASHRAE 15:9.12.5]

1110.3 Support. Stop valves installed in copper refrigerant lines of \( \frac{5}{8} \) of an inch (20 mm) or less outside diameter shall be supported independently of the tubing or piping.

1110.4 Access. Stop valves required by Section 1110.0 shall be readily accessible from the refrigeration machinery room floor or a level platform.

1110.5 Identification. Stop valves shall be identified by tagging in accordance with the reference standard for identification. A valve chart shall be mounted under glass at an approved location near the principal entrance to a refrigeration machinery room.
1109.0 Piping Material.

1109.1 Piping. Refrigerant piping material shall conform to the requirements in this section.

1109.2 Used Materials. Reused pipe, fittings, valves or other materials shall be clean and free of foreign materials and shall be approved by the code official for reuse.

1109.3 Material Rating. Materials, joints and connections shall be rated for the operating temperature and pressure of the refrigerant system. Materials shall be suitable for the type of refrigerant and type of lubricant in the refrigerant system. Magnesium alloys shall not be used in contact with any halogenated refrigerants. Aluminum, zinc, magnesium, or their alloys shall not be used in contact with R-40 (methyl chloride).

1109.4 Piping Materials Standards. Refrigerant pipe shall conform to one or more of the standards listed in Table 1109.4. The exterior of the pipe shall be protected from corrosion and degradation.

<table>
<thead>
<tr>
<th>PIPING MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum Tube</td>
<td>ASTM B210, ASTM B210M, ASTM B491/B491M</td>
</tr>
<tr>
<td>Brass (Copper Alloy)</td>
<td>ASTM B43</td>
</tr>
<tr>
<td>Copper Pipe</td>
<td>ASTM B42, ASTM B302</td>
</tr>
<tr>
<td>Copper Tube(^1)</td>
<td>ASTM B68, ASTM B75, ASTM B88, ASTM B280, ASTM B819</td>
</tr>
<tr>
<td>Copper Linesets</td>
<td>ASTM B1003, ASTM B280</td>
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<tr>
<td>Steel Pipe(^2)</td>
<td>ASTM A53, ASTM A106</td>
</tr>
<tr>
<td>Steel Tube</td>
<td>ASTM A254, ASTM A334</td>
</tr>
</tbody>
</table>

Note 1. Soft annealed copper tubing larger than 1 in. (25 mm) O.D. shall not be used for field assembled refrigerant piping, unless it is protected from mechanical damage.

Note 2. ASTM A53. Type F steel pipe shall not be used for refrigerant lines having an operating temperature less than -20°F (-29°C).

1109.4.1 Steel Pipe Group A2, A3, B2, and B3. The minimum weight of steel pipe for Group A2, A3, B2, and B3 refrigerants shall be Schedule 80 for sizes 1-1/2 inch (40 mm) or less in diameter.

1109.5 Pipe Fittings. Refrigerant pipe fittings shall be approved for installation with the piping materials to be installed and shall conform to one or more of the standards listed in Table 1109.5 or shall be listed and labeled in accordance with UL 207.

<table>
<thead>
<tr>
<th>FITTING MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>ASTM B361</td>
</tr>
<tr>
<td>Brass (Copper Alloy)</td>
<td>ASME B16.15, ASME B16.24</td>
</tr>
<tr>
<td>Steel</td>
<td>ASTM A105, ASTM A181, ASTM A193, ASTM A234, ASTM A420, ASTM A707</td>
</tr>
</tbody>
</table>
1109.5.1 Copper Brazed Field Swaged. The minimum and maximum cup depth of field fabricated copper brazed swaged fitting connections shall comply with Table 1109.5.1.

<table>
<thead>
<tr>
<th>FITTING SIZE (Inch)</th>
<th>MINIMUM (Inch)</th>
<th>MAXIMUM (Inch)</th>
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<tbody>
<tr>
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1109.6 Valves. Valves shall be of materials that are compatible with the type of piping material, refrigerants, and oils in the system. Valves shall be listed and labeled and rated for the temperatures and pressures of the refrigerant systems in which the valves are installed.

1109.7 Flexible Connectors, Expansion and Vibration Compensators. Flexible connectors and expansion and vibration control devices shall be listed and labeled for use in refrigerant systems.

1110.0 Joints and Connections.

1110.1 Approval. Joints and connections shall be of an approved type. Joints and connections shall be tight for the pressure of the refrigerant system when tested in accordance with Section 1116.

1110.1.1 Joints Between Different Piping Materials. Joints between different piping materials shall be made with approved adapter fittings. Joints between dissimilar metallic piping materials shall be made with a dielectric fitting or a dielectric union conforming to dielectric tests of ASSE 1079. Adapter fittings with threaded ends between different materials shall be joined with proper thread lubricant in accordance with Section 1110.3.4.

1110.2 Preparation of Pipe Ends. Pipe shall be cut square, reamed and chamfered, and shall be free of burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

1110.3 Joint Preparation and Installation. Where required by Section 1110.4 through Section 1110.9, the preparation and installation of brazed, flared, mechanical, press-connect, soldered, threaded and welded joints shall comply with Section 1110.3.1 through Section 1110.3.5.
1110.3.1 Brazed Joints. Joint surfaces shall be cleaned. An approved flux shall be applied where required by the braze filler metal manufacturer. The piping being brazed shall be purged of air to remove the oxygen and filled with one of the following inert gases: oxygen-free nitrogen, helium, or argon. The piping system shall be pre-purged with an inert gas for a minimum time corresponding to five volume changes through the piping system prior to brazing. The pre-purge rate shall be at a minimum velocity of 100 feet per minute (0.5 m/s). The inert gas shall be directly connected to the tube system being brazed to prevent the entrainment of ambient air. After the pre-purge, the inert gas supply shall be maintained through the piping during the brazing operation at a minimum pressure of 1.0 psi (6.9 kPa) and a maximum pressure of 3.0 psi (20 kPa). The joint shall be brazed with a filler metal conforming to AWS A5.8.

1110.3.2 Mechanical Joints. Mechanical joints shall be installed in accordance with the manufacturer’s instructions.

1110.3.2.1 Flared Joints. Flared fittings shall be installed in accordance with the manufacturer’s instructions. The flared fitting shall be used with the tube material specified by the fitting manufacturer. The flared tube end shall be made by a tool designed for that operation.

1110.3.2.2 Press-Connect Joints. Press-connect joints shall be installed in accordance with the manufacturer’s instructions.

1110.3.3 Soldered Joints. Joint surfaces shall be cleaned. A flux conforming to ASTM B813 shall be applied. The joint shall be soldered with a solder conforming to ASTM B 32. Solder joints shall be limited to refrigerant systems using Group A1 refrigerant and having a pressure of less than or equal to 200 psi.

1110.3.4 Threaded Joints. Threads shall conform to ASME B1.20.1, ASME B1.20.3, ASME B1.13M, or ASME B1.1. Thread lubricant, pipe-joint compound, or tape shall be applied on the external threads only and shall be approved for application on the piping material.

1110.3.5 Welded Joints. Joint surfaces shall be cleaned by an approved procedure. Joints shall be welded with an approved filler metal.

1110.4 Aluminum Tube. Joints between aluminum tubing or fittings shall be brazed, mechanical, press-connect, or welded joints conforming to Section 1110.3.

1110.5 Brass (Copper Alloy) Pipe. Joints between brass pipe or fittings shall be brazed, mechanical, press-connect, threaded, or welded joints conforming to Section 1110.3.

1110.6 Copper Pipe. Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, press-connect, soldered, threaded, or welded joints conforming to Section 1110.3.

1110.7 Copper Tube. Joints between copper or copper-alloy tubing or fittings shall be brazed, flared, mechanical, press-connect, or soldered joints.

1110.8 Steel Pipe. Joints between steel pipe or fittings shall be mechanical joints, threaded, press-connect, or welded joints conforming to Section 1110.3.

1110.9 Steel Tube. Joints between steel tubing or fittings shall be flared, mechanical, press-connect, or welded joints conforming to Section 1110.3.

1111.0 Refrigerant Pipe Installation.

1111.1 General. Refrigerant piping installations shall comply with the requirements of this section. The design of refrigerant piping shall be in accordance with ASME B31.5.

1111.2 Piping Location. Refrigerant piping shall comply with the installation location requirements of Section 1111.2.1 through Section 1111.2.6. Refrigerant piping for group A2L and B2L shall also comply with the requirements of Section 1111.3. Refrigerant piping for group A2, A3, B2 and B3 shall also comply with the requirements of Section 1111.4.

1111.2.1 Minimum Height. Exposed refrigerant piping installed in open spaces that afford passage shall be not less than 7 feet 3 inches (2210 mm) above the finished floor.

1111.2.2 Refrigerant Pipe Enclosure. Refrigerant piping shall be protected by locating it within either the building elements or protective enclosure.

1111.2.2.1 Enclosure Not Required. Piping protection within the building elements or protective enclosure shall not be required in any of the following locations:
(1) Where installed without ready access or located more than 7 feet 3 inches (2210 mm) above the finished floor.
(2) Where located within 6 feet 0 inches (1830 mm) of the refrigerant unit or appliance.
(3) Where located in a machinery room complying with Section 1105.
1111.2.3 Prohibited Locations. Refrigerant piping shall not be installed in any of the following locations:

(1) Exposed within a fire-resistance-rated exit access corridor.

(2) Interior exit stairway.

(3) Interior exit ramp.

(4) Exit passageway.

(5) Elevator, dumbwaiter or other shaft containing a moving object.

1111.2.4 Piping in Concrete Floors. Refrigerant piping installed in concrete floors shall be encased in pipe, conduit, or ducts. The piping shall be protected to prevent damage from vibration, stress and corrosion.

1111.2.5 Refrigerant Pipe Shafts. Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure. The fire-resistance-rated shaft enclosure shall comply with Building Code. Other building utilities or piping systems shall be allowed in the refrigerant piping shaft.

1111.2.5.1 Shaft Not Required. A Shaft enclosure shall not be required for the refrigerant piping for any of the following systems:

(1) For systems using R-718 refrigerant.

(2) Piping in a direct system using Group A1 refrigerant where the refrigerant quantity does not exceed Table 1103.1 for the smallest occupied space through which the piping passes.

(3) Piping located on the exterior of the building where vented to the outdoors.

1111.2.6 Exposed Piping Surface Temperature. Exposed piping with ready access having temperatures greater than 120°F (49°C) or less than 5°F (-15°C) shall be protected from contact or have thermal insulation which limits the exposed insulation surface temperature to a range of 5°F (-15°C) to 120°F (49°C).

1111.2.7 Pipe Identification. Refrigerant pipe located in areas other than the room or space where the refrigerating equipment is located shall be identified. The pipe identification shall be located at intervals not exceeding 20 feet on the refrigerant piping or pipe insulation. The minimum height of lettering of the identification label shall be ½ inch. The identification shall indicate the refrigerant designation and safety group classification of refrigerant used in the piping system. For Group A2, A3, B2, and B3 refrigerant the identification shall also include the following statement: "DANGER – Risk of Fire or Explosion. Flammable Refrigerant." For any Group B refrigerant, the identification shall also include the following statement: "DANGER - Toxic Refrigerant."

1111.3 Installation Requirements for A2L and B2L Refrigerants. Piping systems using Group A2L or B2L refrigerant shall comply with the requirements of Section 1111.3.1 through Section 1111.3.2.

1111.3.1 Pipe protection. In addition to the requirements in Section 305.5, aluminum, copper, or steel tube for Group A2L and B2L refrigerants located in concealed locations where tubing is installed in studs, joists, rafters or similar member spaces and located less than 1-1/2 inches (38 mm) from the nearest edge of the member, shall be continuously protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575 inch (1.463 mm) (No. 16 gage) shall cover the area of the tube, and shall extend a minimum of 2 inches (51 mm) beyond the outside edge of the tube.

1111.3.2 Shaft Ventilation. Refrigerant pipe shafts with systems using Group A2L or B2L refrigerant shall be naturally or mechanically ventilated. The shaft ventilation exhaust outlet shall comply with Section 501.3.1. Naturally ventilated shafts shall have a minimum of a 4 inch (100 mm) diameter pipe, duct, or conduit that connects at the lowest point of the shaft and connects to the outdoors. The pipe, duct, or conduit shall be level or pitched to the outdoors. Mechanically ventilated shafts shall have a minimum air velocity in accordance with Table 1111.3.2. The mechanical ventilation shall either be continuously operated or activated by a refrigerant detector. Systems utilizing a refrigerant detector shall activate the mechanical ventilation at a maximum refrigerant concentration of 25 percent of the lower flammable limit of the refrigerant. The detector, or a sampling tube that draws air to the detector, shall be located in an area where refrigerant from a leak will concentrate. The shaft shall not be required to be ventilated for double wall refrigerant pipe where the interstitial space of the double wall pipe is vented to the outdoors.
TABLE 1111.3.2
SHAFT VENTILATION VELOCITY

<table>
<thead>
<tr>
<th>CROSS SECTIONAL AREA OF SHAFT (Sq. In)</th>
<th>MINIMUM VENTILATION VELOCITY (feet per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 20</td>
<td>100</td>
</tr>
<tr>
<td>&gt; 20 - = 250</td>
<td>200</td>
</tr>
<tr>
<td>&gt; 250 - = 1250</td>
<td>300</td>
</tr>
<tr>
<td>&gt; 1250</td>
<td>400</td>
</tr>
</tbody>
</table>

1111.4 Installation Requirements for A2, A3, B2, and B3 Refrigerants. Piping systems using Group A2, A3, B2, or B3 refrigerant shall comply with the requirements of Section 1111.4.1 through 1111.4.2.

1111.4.1 Piping Material. Piping material for Group A2, A3, B2, or B3 refrigerant located inside the building, except for machinery rooms, shall be copper pipe, brass pipe, or steel pipe. Pipe joints located in areas other than the machinery room shall be welded. Self-contained listed and labeled equipment or appliances shall have piping material based on the listing requirements.

1111.4.2 Shaft ventilation. Refrigerant pipe shafts with systems using Group A2, A3, B2, or B3 refrigerants shall be continuously mechanically ventilated. The shaft ventilation exhaust outlet shall comply with Section 501.3.1. Mechanically ventilated shafts shall have a minimum air velocity of specified in Table 1111.3.2. The shaft shall not be required to be ventilated for double wall refrigerant pipe where the interstitial space of the double wall pipe is vented to the outdoors.

1111.5 Refrigerant Pipe Penetrations. The annular space between the outside of a refrigerant pipe and the inside of a pipe sleeve or opening in a building envelope wall, floor, or ceiling assembly penetrated by a refrigerant pipe shall be sealed in an approved manner with caulking material, foam sealant or closed with a gasketing system. The caulking material, foam sealant or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve and building materials in contact with the sealing materials. Refrigerant pipes penetrating fire-resistance-rated assemblies or membranes of fire-resistance-rated assemblies shall be sealed or closed in accordance with the Building Code.

1111.6 Stress and Strain. Refrigerant piping shall be installed so as to prevent strains and stresses that exceed the structural strength of the pipe. Where necessary, provisions shall be made to protect piping from damage resulting from vibration, expansion, contraction, and structural settlement.

1111.7 Condensation Control. Refrigerating piping and fittings that, during normal operation, will reach a surface temperature below the dew point of the surrounding air, and are located in spaces or areas where condensation has the potential to cause a safety hazard to the building occupants, structure, electrical equipment or any other equipment or appliances, shall be insulated or protected in an approved manner to prevent damage from condensation.

1111.8 Stop valves. Stop valves shall be installed in specified locations when required in accordance with Section 1111.8.1 and Section 1111.8.2. Stop valves shall be supported in accordance with Section 1111.8.3 and identified in accordance with Section 1111.8.4.

Exceptions:

(1) Systems that have a refrigerant pump out function capable of storing the entire refrigerant charge in a receiver or heat exchanger.
(2) Systems that are equipped with provisions for pump out of the refrigerant using either portable or permanently installed refrigerant recovery equipment.
(3) Self-contained listed and labeled systems.

1111.8.1 Refrigerating Systems Containing More Than 6.6 Pounds (3.0 kg) of Refrigerant. Stop valves shall be installed in the following locations on refrigerating systems containing more than 6.6 pounds (3.0 kg) of refrigerant:

(1) The suction inlet of each compressor, compressor unit or condensing unit.
(2) The discharge outlet of each compressor, compressor unit or condensing unit.
(3) The outlet of each liquid receiver.

1111.8.2 Refrigerating Systems Containing More Than 100 Pounds (45 kg) of Refrigerant. In addition to stop valves required by Section 1111.8.1, systems containing more than 100 pounds (45 kg) of refrigerant shall have stop valves installed in the following locations:
(1) Each inlet of each liquid receiver.

(2) Each inlet and each outlet of each condenser, when more than one condenser is used in parallel.

Exceptions:

(1) Stop valves shall not be required on the inlet of a receiver in a condensing unit, nor on the inlet of a receiver which is an integral part of the condenser.

(2) Systems utilizing nonpositive displacement compressors.

1111.8.3 Stop Valve Support. Stop valves shall be supported to prevent undo stress or strain on the refrigerant piping system. The piping system shall not be utilized to support stop valves on copper tubing or aluminum tubing 1 inch (25 mm) OD or larger in diameter.

1111.8.4 Identification. Stop valves shall be identified where their intended purpose is not obvious. When valves are identified by a numbering or lettering system, legend(s) or key(s) for the valve identification shall be located in the room containing the indoor refrigeration equipment. The minimum height of lettering of the identification label shall be ½ inch (12.7 mm).

(renumber subsequent sections)

1116.0 Testing of Refrigeration Equipment.

1116.1 Factory Tests. Refrigerant-containing parts of unit systems shall be tested and proved tight by the manufacturer at not less than the design pressure for which they are rated. Pressure vessels shall be tested in accordance with Section 1117.0. [ASHRAE 15:9.14.1]

1116.1.1 Testing Procedure. Tests shall be performed with dry nitrogen or another nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them shall not be used. The means used to build up the test pressure shall have a pressure-limiting device or a pressure-reducing device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system’s components.

Exceptions:

(1) Mixtures of dry nitrogen, inert gases, nonflammable refrigerants permitted for factory tests.

(2) Mixtures of dry nitrogen, inert gases, or a combination of them with flammable refrigerants in concentrations not exceeding the lesser of a refrigerant weight fraction (mass fraction) of 5 percent or 25 percent of the LFL shall be permitted for factory tests.

(3) Compressed air without added refrigerant shall be permitted for factory tests provided the system is subsequently evacuated to less than 0.039 inch of mercury (0.132 kPa) before charging with refrigerant. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the refrigerant. [ASHRAE 15:9.14.1.1]

1116.1.2 Applied Pressure. The test pressure applied to the highside of each factory-assembled refrigerating system shall be not less than the design pressure of the highside. The test pressure applied to the lowside of a factory-assembled refrigerating system shall be not less than the design pressure of the lowside.

[ASHRAE 15:9.14.3]

1116.2 Field Tests. Refrigerant-containing parts of a system that is field-erected shall be tested and proved tight after complete installation and before the operation. The high and low sides of each system shall be tested and proved tight at not less than the lower of the pressure in Table 1116.2 or the setting of the pressure-relief device.

Exceptions:

(1) Compressors, condensers, evaporators, coded pressure vessels, safety devices, pressure gauges, control mechanisms, and systems that are factory tested.

(2) Refrigeration systems containing Group R-22, not exceeding 5 tons of refrigeration capacity (18 kW), and field-piped using approved, factory-charged line sets shall be permitted to be proved tight by observing retention of pressure on a set of charging gauges and soaping connections while the system is operating.
TABLE 1116.2
FIELD LEAK TEST PRESSURES (psig)*

<table>
<thead>
<tr>
<th>REFRIGERANT NUMBER</th>
<th>HIGHSIDE WATER COOLED</th>
<th>HIGH-SIDE AIR COOLED</th>
<th>LOWSIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>15</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>12</td>
<td>140</td>
<td>220</td>
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<td>15</td>
</tr>
<tr>
<td>134a</td>
<td>150</td>
<td>250</td>
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</tr>
<tr>
<td>152a</td>
<td>130</td>
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<tr>
<td>500</td>
<td>165</td>
<td>265</td>
<td>1465</td>
</tr>
<tr>
<td>502</td>
<td>250</td>
<td>385</td>
<td>250</td>
</tr>
<tr>
<td>744</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

For SI units: 1 pound-force per square inch gauge = 6.8947 kPa
* Special design required; test pressures typically exceed 1000 psig (6895 kPa).

1116.0 Refrigerant Piping System Test.

1116.1 General. Refrigerant piping systems erected in the field shall be pressure tested for strength and leak tested for tightness, after installation and before being placed in operation, in accordance with the requirements of this section. Tests shall include both the high and low-pressure sides of each system.

1116.1.1 Testing Not Required. Listed and labeled equipment, including compressors, condensers, vessels, evaporators, gas bulk storage tanks, safety devices, pressure gauges and control mechanisms, shall not be required to be tested.

1116.2 Exposure of Refrigerant Piping System. Refrigerant pipe and joints installed in the field shall be exposed for visual inspection and testing prior to being covered or enclosed.

1116.3 Test Gases. The medium used for pressure testing the refrigerant system shall be one of the following inert gases: oxygen-free nitrogen, helium, or argon. For R-744 refrigerant systems carbon dioxide shall be allowed as the test medium. For R-718 refrigerant systems water shall be allowed as the test medium. Oxygen, air, combustible gases and mixtures containing such gases shall not be used as test medium. Systems erected on the premises with tubing not exceeding 5/8 inch (15.8 mm) OD shall be allowed to use the refrigerant identified on the nameplate label or marking as the test medium.

1116.4 Test Apparatus. The means used to pressurize the refrigerant piping system shall have either a pressure-limiting device or a pressure-reducing device and a test pressure measuring device on the outlet side. The test pressure measuring device shall have an accuracy of ±3 percent or less of the test pressure, and shall have a resolution of 5 percent or less of the test pressure.

1116.5 Piping System Pressure Test and Leak Test. The refrigerant piping system shall be tested, however, separate tests for low-side and high-side sections of the piping system shall be allowed. The refrigerant piping system shall be tested in accordance with both of the following methods:

(1) Pressurized for a minimum of 60 minutes to not less than the lower of the design pressures or the setting of the pressure relief device(s). The design pressures for testing shall be the pressure listed on the label nameplate of the condensing unit, compressor, compressor unit, pressure vessel, or other system component with a nameplate. No additional test gas shall be added to the system after the start of the pressure test. The system shall show no loss of pressure on the test pressure measuring device during the pressure test. When using refrigerant as a test medium in accordance with Section 1116.3, the test pressure shall be not less than the saturation dew point pressure at 77°F (25°C).

(2) A vacuum of 500 microns shall be achieved. After achieving a vacuum, the system shall be isolated from the vacuum pump. The system pressure shall not rise above 1500 microns for a minimum period of 10 minutes.

1116.5.1 Joints and Refrigerant-Containing Parts in Air Ducts. Joints and all refrigerant-containing parts of a refrigerating system located in an air duct of an air-conditioning system carrying conditioned air to and from human-occupied space shall be
tested at a pressure of 150 percent of the higher of the design pressure or pressure relief device setting.

1116.5.2 Limited Charge Systems. Limited-charge systems with a pressure relief device, erected on the premises, shall be tested at a pressure not less than one and one-half times the pressure setting of the relief device. Listed and labeled limited charge systems shall be tested at the equipment or appliance design pressure.

1116.6 Booster Compressor. Where a compressor protected by a pressure relief device is used as a booster to obtain an intermediate pressure and discharges into the suction side of another compressor, the booster compressor shall be considered a part of the low side.

1116.7 Centrifugal/Nonpositive Displacement Compressors. When testing systems using centrifugal or other nonpositive displacement compressors, the entire system shall be considered the low-side pressure for test purposes.

1116.8 Contractor or Engineer Declaration. The installing contractor or registered design professional of record shall issue a certificate of test to the code official for all systems containing 55 pounds (25 kg) or more of refrigerant. The certificate shall give the test date, name of the refrigerant, test medium, and the field test pressure applied to the high-side and the low-side of the system. The certification of test shall be signed by the installing contractor or registered design professional and shall be made part of the public record.

<table>
<thead>
<tr>
<th>TABLE 1701.1</th>
<th>REFERENCED STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD NUMBER</td>
<td>STANDARD TITLE</td>
</tr>
<tr>
<td>ASME B1.1-2003</td>
<td>Unified Inch Screw Threads</td>
</tr>
<tr>
<td>ASME B1.13M</td>
<td>Metric Screw Threads; M Profile</td>
</tr>
<tr>
<td>ASTM A105/A105M-2014</td>
<td>Carbon Steel Forgings for Piping Applications</td>
</tr>
<tr>
<td>ASTM A181-2014</td>
<td>Carbon Steel Forgings for General-Purpose Piping</td>
</tr>
<tr>
<td>ASTM A193/A193M-2017</td>
<td>Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications</td>
</tr>
<tr>
<td>ASTM A234/A234M-2018</td>
<td>Piping Fittings of Wrought Carbon Steel and Alloy-Steel for Moderate and High Temperature Service</td>
</tr>
<tr>
<td>ASTM A334/A334M-2004a (R2016)</td>
<td>Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service</td>
</tr>
<tr>
<td>ASTM A707/A707M-2014</td>
<td>Forged Carbon and Alloy Steel Flanges for Low-Temperature Service</td>
</tr>
<tr>
<td>ASTM B68/ASTM B68M-2011</td>
<td>Seamless Copper Tube, Bright Annealed</td>
</tr>
<tr>
<td>ASTM B210M-2012</td>
<td>Aluminum and Aluminum-Alloy Drawn Seamless Tubes (Metric)</td>
</tr>
<tr>
<td>ASTM B361-2016</td>
<td>Factory-Made Wrought Aluminum and Aluminum-Alloy Welding Fittings</td>
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<tr>
<td>ASTM B491/B491M-2015</td>
<td>Aluminum and Aluminum-Alloy Extruded Round Tubes for General-Purpose Applications</td>
</tr>
<tr>
<td>ASTM B819-2018</td>
<td>Seamless Copper Tube for Medical Gas Systems</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTION:
I organized a group of 8 experts in the field of refrigerant piping to help develop this code change. I refer to them as the Refrigerant Piping Committee. However, I am submitting this change as the proponent. In addition to the Committee I created, I circulated a draft to other experts in the field of refrigeration. I received a number of comments through that review. Those comments have been incorporated in the final text that I am submitting. It is the intent of the Refrigerant Piping Committee to submit a similar change to ASHRAE 15. A change has already been submitted to the IMC. The goal is to update all refrigerant piping requirements addressing every type of refrigerant system other than ammonia. This proposed change reorganizes and updates the existing refrigerant piping requirements. Many of the requirements remain the same as in the current code. This section follows the Manual of Style for listing piping material, joints, and connections, and installation requirements. Section 1109 is the piping material section. Section 1109.1 is the general section indicating that compliance to the section for material requirements. It should be understood that ammonia piping requirements are regulated by IAR. The code currently requires compliance with IAR 2 for ammonia systems. Hence, these requirements do not cover ammonia refrigerant piping systems. There is currently no section regarding used materials, yet other chapters include requirements for used materials. This section requires that approved material be used for the temperatures, pressures, and type of refrigerant. The aluminum, zinc, and magnesium alloys exception for R-40 (methyl chloride) is the same as the current Section 1109.1. The same is true for magnesium alloys for which cannot be used with any halogenated refrigerants since the material will react and fail. Section 1109.4 includes a table for listing all of the acceptable piping material. The appropriate standards for the piping material are listed in the table. The soft brass was previously converted to copper alloy throughout the code, ASTM B43 is still identified as a brass pipe standard. Therefore, brass was used with copper alloy included in parenthesis. The current code has a restriction on the use of mechanical joints with annealed copper tubing. This is a hold over requirement that is out of date. ASME B31.5 has a different limitation. Note 1 to the table includes the requirements listed in ASME B31.5. Note 2 of the table currently appears in the code. The requirement remains the same. Section 1109.5 includes a table of the fitting standards used in refrigerant piping systems. Some of the standards are new to this chapter since the previous requirements were weak with regard to referencing the appropriate fitting standards. There is also a general reference to UL 207. There are refrigerant fittings that do not meet standard fitting, however, they are listed to UL 207. This is an appropriate standard for specialty type of refrigerant fittings. Copper tubing is a common material used in refrigerant piping systems. A common joint is a swaged fitting which is made in the field. Since the swaging of copper expands the wall of the tube, there is weakening the outer tube of the joint where unsupported by the joint filler material and inner tube. The depth of the swage must be included. This depth is similar to the brazed fitting cup depths in the ASME B16.50 standard. The maximum depth allows a 50% increase in cup depth. A greater depth will result in too weak a pipe wall. Section 1109.6 adds requirements for valves. The current code has valve installation requirements but is missing valve material requirements. Section 1109.7 adds material requirements for flexible connectors and expansion and vibration compensators. These components are required to be listed and labeled for refrigerant systems. Section 1110 is organized with general requirements in the beginning, followed by joining methods, and completed with piping material allowances of various joining methods. Many of the requirements are new since the current code requirements are not up to date. Section 1110.1 is the general section requiring all joints to be approved and meet the tightness requirements to pass the system test. Section 1110.1.1 lists requirements for joints between different materials. A reference to the testing requirements in ASSE 1079 is made in the section for joints between dissimilar metals. The standard has appropriate testing requirements for dielectric tests that can be used on refrigeration piping systems even though the standard appears to address water piping systems. Section 1110.2 is similar to the preparation of pipe ends found in other chapters. The same requirements would apply to refrigerant piping. Section 1110.3 is acceptable joining methods, excluding an ing joining methods. For brazing methods, the filler metal is applied and the area is heated up to the brazing temperature on the interior of the piping. If there is excessive oxidation, it could result in obstruction of small piping or components in the system, as well as other system chemistry degradation, increasing the probability of future repair work. Reducing the frequency of opening refrigeration systems for repair reduces the exposure to numerous hazards and risks. For many of the joints, a reference to UL 207 is included. This standard covers the various refrigerant joining methods. The press-connect refrigerant fittings are listed to this standard, as are many mechanical joints. Section 1110.3.4 includes all of the various threads that are used in refrigerant piping systems. This expands the listing of ASME standards for threaded joints. Section 1110.4 through 1110.5.5 list piping material allowances of various joining methods. These allowances are listed in a separate section from the material and joints and connections. The piping requirements have been expanded to address the necessary safety measures to assure a proper piping installation. With a greater use of VRV and VRF systems, there is significantly more refrigerant piping installed inside a building. Additionally, with split systems and multi-split systems in multi-story residential buildings, there is also a significant amount of piping installed. There will be an expanded use of Group A2 refrigerants that are low global warming potential refrigerants. These refrigerants were previously listed as a subgroup of A2 refrigerants. As a separate group, the requirements need to be provided to address the installation of piping with Group A2 refrigerants. The new section also includes piping for Group A2L refrigerants. The next part is for piping requirements for Group A2, A3, B2, and B3 refrigerants. The last part has additional general requirements for piping installations. Section 1111.1 includes a reference to ASME B31.5. This standard is currently referenced in Section 1109.1. There is no change regarding the application of ASME B31.5. Section 1111.2 identifies which sections are applicable to which refrigerant groups. Section 1111.2.1 is a rewording of the requirements currently found in Section 1109.2.1. Section 1111.2.2 is a new section listing elements that are not included in the current code, it is not stated. Section 1111.2.2.1, allowing refrigerant piping to be exposed, is similar to the current allowance specified in Section 1109.4 and Section 1109.4.1. The other allowance would be refrigerant piping located in a machinery room. Exposed piping is anticipated in a machinery room where access is restricted to authorized personnel. Section 1111.2.3 is similar to current Section 1109.2. One of the changes is the allowance for refrigerant piping to be located in the ceiling of a corridor, hence, not exposed. This appears to be implied, however, when the ceiling space is considered a part of the corridor, it appears to be prohibited. Refrigerant piping, especially for multi-split systems is often installed in the ceiling of a corridor. If the RCL requirements are met, there is no hazard posed to the corridor. Section 1111.2.4 is a duplication of the requirements currently found in Section 1109.5.1. Section 1111.2.5 is a new section regulating the requirements for shaft containing refrigerant piping. A fire-resistance-rated shaft will be required when the refrigerant piping connects three or more stories. Other utilities can also be located within the same shaft. There are three exceptions proposed to the shaft requirements in Section 1111.2.5.1, one is when water is used, that is R718 refrigerant. The second is for the use of Group A1 refrigerants provided the smallest space in which the pipe pass meets the RCL requirements for the refrigerant. The last exception would be the piping in a machinery room. Section 1111.3 is a new section allowing a depth of 6 inches in a new section. This section is intended to protect an individual from directly contacting a hot or cold refrigerant pipe. The temperatures are based on avoiding burning the skin or causing frostbite or frost damage to the skin. One of the methods of protection would be adding insulation around the pipe. This is the most common method of protection for exposed piping. Section 1111.2.7 lists the piping material that is used for Group B refrigerant piping. This is toxic, there are special requirements to label the pipe as containing toxic refrigerant. For flammable refrigerants, Group A2 and A3, the piping is not flammable and there is a risk of fire or explosion. Section 1111.3 is a new section regulating the installation of piping using Group A2 or B2 refrigerants. These refrigerants are lower flammable, lower burning velocity refrigerants. While the refrigerant will burn, it doesn’t ignite or burn very easily. Since it is flammable additional protection requirements are proposed. Section 1111.3.1 will require continuous protection when the piping is located within 1-1/2 inches of the nearest edge of a member. Currently the code requires a level of protection in Section 316 for certain locations, such as the top plate and bottom plate. This section will require the protection where ever the piping is installed. The protection is intended to prevent the tubing from being punctured by a nail or screw. Section 1111.3.2 requires ventiliation of the shaft in which the refrigerant piping is located. A minimal movement of air will exhaust the leaking refrigerant out of the shaft. The velocity rates identified in Table 1111.3.2-1 are taken from a peer reviewed paper published by ASME that ensure that neutral differences between air and refrigerant will not defeat the purpose to exhaust the released refrigerant out of the shaft, whether in horizontal or vertical shaft orientation. The ventilation would only be required when there is a leak of refrigerant. A leak detector is required in the shaft to identify when a leak occurs. Another option would be to naturally ventilate the shaft or continuously ventilate the shaft. Since most refrigerants are heavier than air, they tend to move downward. If naturally ventilated, the refrigerant moves to outside the building. An exception to the ventilation requirements would be the use of double wall pipe. While this is not commonly installed, the possibility exists that there will be greater use of double wall pipe. Section 1111.4 has the special requirement for the more flammable and more toxic refrigerants. Section 1111.4.1 requires the systems to be installed using pipe, not tubing. The added strength of the
Pipe will reduce any potential leak from a puncture. The exception to this requirement would be self-contained listed equipment. Some refrigerators and similar appliances are using Group A3 refrigerants. However, these appliances are tested and listed. Section 1111.4.2 requires any shaft with these refrigerants to be continuously ventilated. The same velocity requirements apply to this group of refrigerants as Group A2L and B2L. There is also an exception for double wall pipe. Section 1111.5 is a new section regulating pipe penetrations. Any time a pipe penetrated a wall, floor, or ceiling, it must be sealed to prevent the passage of any refrigerant that may be leaking. There is a direct reference to the building code for penetrations of fire-resistance-rated assemblies. Section 1111.6 is a new requirement for pipe protection. These requirements are similar to other piping systems in the Mechanical Code and the Plumbing Code. The requirements are also applicable to refrigerant piping. Section 1111.7 through Section 1111.8.4 are rewording and relocation of current Section 1109.9, Section 1109.10, and Section 1110.0. The Refrigerant Piping Committee spent a considerable amount of time rewriting and discussing the testing requirements. The basis for Section 1116 is the current Section 1116. The key elements of Section 1116 are captured in the new section. The significant differences relate to the test medium, the test equipment, and the pressure and vacuum test. The test gas is specified as being either oxygen-free nitrogen, helium, or argon. These are the three inert gases used for testing refrigerant piping systems. Carbon dioxide refrigerant systems are permitted to be tested with carbon dioxide. Water refrigerant piping systems are permitted to be tested with water. For smaller systems, refrigerant contractors have used the refrigerant for testing. This would be permitted for systems having 5/8 inch or smaller tubing. The accuracy of the test gage is not currently specified. Most test gages used by refrigerant contractors have an accuracy within 2-1/2 percent. The allowance for up to 3 percent takes into consideration other gages that may be used. For the testing of the system, the Committee believes it is important to run two tests; one is a pressure test, the other is a vacuum test. When testing with internal pressures, a one-way leak in the reverse direction may not be discovered. However, when a vacuum is placed on the system, the leak will be identified. The standard test for refrigerant systems is one hour for pressure and 10 minutes for a vacuum. These tests have been added to the section.

**COMMITTEE ACTION:** REJECT

**COMMITTEE STATEMENT:**
The proposed change contains overly stringent language. Furthermore, Table 1109.5.1 is overly restrictive and is not user-friendly.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Proposals

Item #: 097

UMC 2021 Section: 1109.1, 1109.1.2

SUBMITTER: William Chapin
Professional Code Consulting, LLC

RECOMMENDATION:
Revise text

1109.0 Refrigeration Piping, Containers, and Valves.

1109.1 Materials. Materials used in the construction and installation of refrigerating systems shall be compatible with the conveying refrigerant used. Materials shall not be used that will deteriorate due to the chemical action of the refrigerant, lubricant, or combination of both where exposed to air or moisture to a degree that poses a safety hazard. [ASHRAE 15:9.1.1] Refrigerant piping shall be metallic.

1109.1.2 Copper Linesets. Copper linesets shall comply with ASTM B280 or ASTM B1003. PE-RT/AL/PE-RT linesets shall be permitted when in compliance with ASTM FXXXX.

Note: ASTM FXXXX is a working draft and is not completed at the time of this monograph.

SUBSTANTIATION:
This revision makes way for the reference of PE-RT/AL/PE-RT tubing that is being used for refrigeration line sets Nationwide. This tubing is tested and listed for specific refrigerants and temperature and pressure requirements. This standard is to be published well before the 2021 code cycle is completed.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed standard ASTM FXXXX is a working draft and was not completed at the time this monograph was published.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
CHAPTER 2
DEFINITIONS

220.0  — R —

Refrigeration System, Indirect. A system in which a secondary coolant cooled or heated by the refrigerating system is circulated to the air or other substance to be cooled or heated. Indirect systems are distinguished by the method of application given below. [ASHRAE 15:5.1.2]

- **Indirect Open Spray System.** A system in which a secondary coolant is in direct contact with the air or other substance to be cooled or heated. [ASHRAE 15:5.1.2.1]
- **Double Indirect Open Spray System.** A system in which the secondary substance for an indirect open spray system is heated or cooled by the secondary coolant circulated from a second enclosure. [ASHRAE 15:5.1.2.2]
- **Indirect Closed System.** A system in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated. [ASHRAE 15:5.1.2.3]

1111.0 Pressure-Limiting Devices.

1111.1 Where Required. Pressure-limiting devices complying with Section 1111.2 through Section 1111.4 shall be provided for compressors on all systems operating above atmospheric pressure.

Exception: Pressure limiting devices are not required for listed factory-sealed systems containing less than 22 pounds (9.9 kg) of Group A1 refrigerant listed by an approved agency. [ASHRAE 15:9.9.1]

1111.2 Setting. Where required in Section 1111.1, the maximum setting to which a pressure-limiting device is capable of being readily set by use of the adjusting means provided shall not exceed the design pressure of the highside of a system that is not protected by a pressure relief device or 90 percent of the setting of the pressure-relief device installed on the highside of a system. The pressure-limiting device shall stop the action of the pressure-imposing element at a pressure not more than the maximum setting.

Exception: On systems using nonpositive displacement compressors, the maximum setting of the pressure-limiting device shall not be required to be less than the design pressure of the highside of the system provided the pressure-relief device is located in the lowside, subject to lowside pressure, and there is a permanent (unvalved) relief path between the highside and the lowside of the system.

Pressure limiting devices shall be set in accordance with one the following:

1. For positive displacement compressors:
   a. When systems are protected by a highside pressure relief device, the compressor’s pressure limiting device shall be set not more than 90 percent of the operating pressure for the highside pressure relief device.
   b. When systems are not protected by a highside pressure relief device, the compressor’s pressure limiting device shall be set not more than the system’s highside design pressure.

2. For nonpositive displacement compressors:
(a) When systems are protected by a highside pressure relief device, the compressor’s pressure limiting device shall be set not more than 90 percent of the operating pressure for the highside pressure relief device.
(b) When systems are protected by a lowside pressure relief device that is only subject to lowside pressure, and is provided with a permanent relief path between the systems’ highside and lowside, without intervening valves, the compressor’s pressure limiting device shall be set not more than the systems’ highside design pressure. [ASHRAE 15:9.9.2]

1111.3 **Connection Location.** Pressure limiting devices shall be connected between the pressure imposing element and the stop valve on the discharge side. There shall be no intervening stop valves in the line leading to the pressure limiting device. Stop valves shall not be installed between the pressure imposing element and pressure limiting devices serving compressors. [ASHRAE 15:9.9.3]

1111.4 **Operation Emergency Stop.** Where the system is protected by a pressure relief device, the pressure limiting device shall stop the action of the pressure-imposing element at a pressure not exceeding 90 percent of the setting of the pressure relief device. Activation of a pressure-limiting device shall stop the action of the pressure-imposing element. [ASHRAE 15:9.9.4]

1112.0 **Pressure-Relief Devices.**

1112.4 **Evaporators.** Heat exchanger coils located downstream, or upstream within 18 inches (457 mm), of a heating coil source and capable of being isolated shall be fitted with a pressure-relief device discharging that discharges to another part of the system in accordance with Section 1112.5 through Section 1112.5.2 or outside the building or any enclosed space in accordance with the requirements of Section 1112.10. The pressure relief device shall be connected at the highest possible location of the heat exchanger or piping between the heat exchanger and its manual isolation valves.

**Exceptions:**

(1) Relief valves shall not be required on heating heat exchanger coils that are designed to produce a temperature that will result in the have a design pressure more than 110 percent of refrigerant saturation pressure of the refrigerant being less than the design pressure when exposed to the maximum heating source temperature.

(2) A relief valve shall not be required on self-contained or unit systems where the volume of the lowside of the system, which is shut off by valves, is more than the specific volume of the refrigerant at critical conditions of temperature and pressure, as determined in accordance with Equation 1112.4.

\[
V_1 / [W_1 - (V_2 - V_1) / V_{gt}] > V_{gc}
\]

**(Equation 1112.4)**

\[V_1\] = Lowside volume, cubic foot (m\(^3\)).
\[V_2\] = Total volume of system, cubic foot (m\(^3\)).
\[W_1\] = Total weight of refrigerant in system, pounds (kg).
\[V_{gt}\] = Specific volume of refrigerant vapor at 110°F (43°C), cubic feet per pound (m\(^3\)/kg).
\[V_{gc}\] = Specific volume at critical temperature and pressure, cubic feet per pound (m\(^3\)/kg). [ASHRAE 15:9.4.4]

1112.5 **Hydrostatic Expansion.** Pressure rise resulting from hydrostatic expansion due to temperature rise of liquid refrigerant trapped in or between closed valves shall be addressed in accordance with Section 1112.5.1 and Section 1112.5.2. [ASHRAE 15:9.4.3]

1112.5.1 **Hydrostatic Expansion During Normal Operation.** Where trapping of liquid with subsequent hydrostatic expansion is capable of occurring automatically during normal operation or during standby, shipping, or power failure, engineering controls shall be used that are capable of preventing the pressure from exceeding the design pressure. Acceptable engineering controls include but are not limited to the following:

(1) Pressure relief device to relieve hydrostatic pressure to another part of the system.

(2) Reseating pressure relief valve to relieve the hydrostatic pressure to an approved treatment system. [ASHRAE 15:9.4.3.1]

1112.5.2 **Hydrostatic Expansion During Maintenance.** Where trapping of liquid with subsequent hydrostatic expansion is capable of occurring only during maintenance—i.e., when personnel are performing maintenance tasks—either engineering or administrative controls shall be used to relieve or prevent the hydrostatic overpressure. [ASHRAE 15:9.4.3.2]

(renumber remaining sections)

**SUBSTANTIATION:**
Technical Merit: Current requirements in Chapter 11 were extracted from ASHRAE 15-2016. The modifications clarify the wording in Section 1112.4, and add specific requirements for hydrostatic expansion that occur during normal operation and during maintenance. Additionally, the inequality sign from Equation 1112.4 is removed to clarify that the value of Equation 1112.4 must be greater than “Vgc.” The updates include a revision for pressure limiting devises to include specific installation locations and pressure requirements. Additionally, specific indirect systems are defined based on the system configuration based on method of application that will assist the end user specify the type of indirect system. Emergency nature: The emergency nature of this proposed TIA is supported by Section 5-2(a) of the Regulations Governing Committee Projects, “The document contains an error or an omission that was overlooked during a regular revision process.” The current Uniform Mechanical Code does not distinguish between hydrostatic expansion during maintenance and normal operation which can lead to confusion in regards to applying the appropriate method of relieving or controlling hydrostatic expansion. Clarification of the inequality of Equation 1112.4 removes confusion and ambiguity for when a relief may not be required, depending on the refrigerant volume. Furthermore, the updates include specific settings for pressure relief devices, based on the system configuration. The modifications are based on ASHRAE 15-2016, latest edition, which is currently referenced for the 2018 edition of the UMC.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Proposals

Item #: 099

UMC 2021  Section: 1127.0, 1127.1, Table 1701.1

SUBMITTER: Billy Smith
ASPE

RECOMMENDATION:
Add new text

1127.0 Operation and Maintenance.
1127.1 General. Cooling towers shall be operated and maintained in accordance with ASHRAE 188.

TABLE 1701.1
REFERRED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE 188-2015</td>
<td>Legionellosis: Risk Management for Building Water Systems</td>
<td>Miscellaneous</td>
<td>1127.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ASHRAE 188 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
Cooling towers have been identified as an opportunistic environment for Legionella bacteria growth and release to the environment where people risk exposure to the organisms and the resulting health effects. ASHRAE standard 188 provides specific Legionella risk mitigation elements for cooling towers and the related mechanical components. The standard provides for an initial evaluation of the system and ongoing measures to reduce human exposure/risk to the bacteria.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is a maintenance requirement and is not within the scope of the UMC.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  ABSTAIN: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF ABSTAIN:

EGG: Cooling towers can spread Legionella and pose a risk to health and human safety and should have some identification in the UMC
Item #: 100
UMC 2021  Section: 1201.3

SUBMITTER: Lance MacNevin, P.Eng.
        Plastic Pipe Institute

RECOMMENDATION:
Revise text

1201.0 General.

1201.3 Water Hammer Protection. The flow of the hydronic piping system shall be designed controlled to prevent water hammer.

SUBSTANTIATION:
The revision to Section 1201.3 will provide clarity as to how water hammer protection is to be provided. Water hammer is provided to control the flow of the hydronic system. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is being rejected as the system should be designed to eliminate water hammer. The TC does not agree with the substantiation.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

HYDE: I believe that the similar code sections shared between the UMC and USHGC should be consistent.
**TABLE 1203.2**
WATER HEATERS

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

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

**SUBSTANTIATION:**
Table 1203.2 is being revised to include the proper titles for the application. This is necessary for the ease of use of the code.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 26
Item #: 102

UMC 2021  Section: 1308.5.8.1

SUBMITTER: Mohamed Dano
Control Air Conditioning Corporation

RECOMMENDATION:
Revise text

1308.0 Gas Piping System Design, Materials, and Components.

1308.5 Acceptable Piping Materials and Joining Methods. (remaining text unchanged)

1308.5.8 Metallic Piping Joints and Fittings. (remaining text unchanged)
1308.5.8.1 Pipe Copper, Copper Alloy, and Stainless Steel Tubing Joints. Pipe Copper, copper alloy, or stainless steel tubing joints shall be threaded, flanged, brazed, welded, or press-connect fittings made in accordance with CSA LC-4. The tubing shall be assembled with an approved fitting. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus. Brazing alloys and fluxes shall be permitted to be used where approved by the manufacturer for use on stainless steel alloy tubing joints.

SUBSTANTIATION:
Section 1308.5.8.1 is being revised for consistency throughout the code. This will provide consistency throughout the industry in regards to the joining of copper, copper alloy, and stainless steel materials used in fuel gas piping systems.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

1308.0 Gas Piping System Design, Materials, and Components.

1308.5 Acceptable Piping Materials and Joining Methods. (remaining text unchanged)

1308.5.8 Metallic Piping Joints and Fittings. (remaining text unchanged)
1308.5.8.1 Copper, Copper Alloy, and Stainless Steel Tubing Joints. Copper, copper alloy, or stainless steel tubing joints shall be threaded, flanged, brazed, welded, or press-connect fittings made in accordance with CSA LC-4. The tubing shall be assembled with an approved fitting. The brazing materials shall have a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus. Brazing alloys and fluxes shall be permitted to be used where approved by the manufacturer for use on stainless steel alloy tubing joints.

COMMITTEE STATEMENT:
The proposed text is being deleted in favor of Item # 145.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 103

UMC 2021  Section: 1209.1 - 1209.2

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1209.0 Expansion Tanks.

1209.1 General. An expansion tank shall be installed in each closed hydronic system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed or open type. Expansion tanks shall be rated for the pressure of the system.

1209.2 Installation. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating 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 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.

SUBSTANTIATION:
The revision to Section 1209.1 and Section 1209.2 will provide clarity in regard to expansion tanks. Furthermore, the modification will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 104
UMC 2021  Section: Table 1210.1, Table 1701.1, Table 1701.2

SUBMITTER: Mark Fasel
Viega LLC

RECOMMENDATION:
Revise text

### TABLE 1210.1
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
<th>FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PIPING/TUBING</td>
<td>FITTINGS</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>ASTM A269</td>
<td>IAPMO PS 117</td>
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<tr>
<td></td>
<td>ASTM A312</td>
<td>ASTM F3226</td>
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<tr>
<td></td>
<td>ASTM A554</td>
<td>ASTM A312</td>
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<td>ASTM A778</td>
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### TABLE 1701.1
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>ASTM A269/A269M-2015a</td>
<td>Seamless and Welded Austenitic Stainless Steel Tubing for General Service</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM A312/A312M-2017</td>
<td>Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
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<tr>
<td>ASTM A554-2016</td>
<td>Welded Stainless Steel Mechanical Tubing</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
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<tr>
<td>ASTM A778/A778M-2016</td>
<td>Welded, Unannealed Austenitic Stainless Steel Tubular Products</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM F3226/F3226M-2016</td>
<td>Metallic Press-Connect Fittings for Piping and Tubing Systems</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM F1476-2007(R2013)</td>
<td>Performance of Gasketed Mechanical Couplings for Use in Piping Applications</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM F1548-2001(R2012)</td>
<td>Performance of Fittings for Use with Gasketed Mechanical Couplings Used in Piping Applications</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>IAPMO PS 117-2017</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
</tbody>
</table>
(portion of table not shown remains unchanged)

Note: ASTM A269/A269M, ASTM A312/A312M, ASTM A554, ASTM A778/A778M, ASTM F3226/F3226M, ASTM F1476, ASTM F1548, and IAPMO PS 117 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

### TABLE 1701.2
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 A312/A312M-2016a</td>
<td>Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</td>
<td>Piping, Ferrous</td>
</tr>
<tr>
<td>ASTM F1476-2007 (R2013)</td>
<td>Performance of Gasketed Mechanical Couplings for Use in Piping Applications</td>
<td>Joints</td>
</tr>
<tr>
<td>IAPMO PS 117-2012a</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**SUBSTANTIATION:**
Stainless Steel piping and tubing has been requested for use by designers due to its corrosion resistance properties. Currently Table 1210.1 does not recognize stainless steel in the referenced Materials. Proposed Fitting Standards are all open consensus standards that include Piping and tubing fittings as well as Press and Nail Connections and Press-Connect fittings. The inclusion of Stainless Steel pipe and tubing for hydronic use will satisfy the demand for materials that have a higher corrosion resistance than standard steel piping. The standards referenced in this proposal are also proposed to be added to Referenced Standards Table 1701.1 Stainless Steel is being requested for use in Hydronic Systems and currently Table 1210.1 does not recognize the stainless steel as an acceptable material. Stainless steel piping and tubing is more than adequate for hydronic piping and tubing and are desired for use due to their corrosion resistance properties. Proposed Fitting Standards are all open consensus standards that include Piping and tubing fittings as well as Press and Nail Connections and Press-Connect fittings. These standards for piping, tubing and fittings must be included into Table 1701.1 when referenced into the body of the code which for these standards will be Table 1210.1 Materials for Hydronic System Piping, Tubing and Fittings.

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

Amend proposal as follows:

### TABLE 1210.1
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASTM A269</td>
</tr>
<tr>
<td></td>
<td>ASTM A312</td>
</tr>
<tr>
<td></td>
<td>ASTM A554</td>
</tr>
<tr>
<td></td>
<td>ASTM A778</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

### TABLE 1701.1
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>ASTM A269/A269M-2015a</td>
<td>Seamless and Welded Austenitic Stainless Steel Tubing for General Service</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM A312/A312M-2017</td>
<td>Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM A554-2016</td>
<td>Welded Stainless Steel Mechanical Tubing</td>
<td>Piping, Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>Standard</td>
<td>Description</td>
<td>Category</td>
<td>Table</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------</td>
<td>-------</td>
</tr>
<tr>
<td>ASTM A778/A778M-2016</td>
<td>Welded, Unannealed Austenitic Stainless Steel Tubular Products</td>
<td>Piping-Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM F3226/F3226M-2016</td>
<td>Metallic Press-Connect Fittings for Piping and Tubing Systems</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM F1476-2007 (R2013)</td>
<td>Performance of Gasketed Mechanical Couplings for Use in Piping Applications</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>ASTM F1548-2001 (R2012)</td>
<td>Performance of Fittings for Use with Gasketed Mechanical Couplings Used in Piping Applications</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
<tr>
<td>IAPMO PS 117-2017</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
<td>Table 1210.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**COMMITTEE STATEMENT:**
The proposed modification corrects the application of the standards to apply to piping only.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**  
AFFIRMATIVE: 25  
NOT RETURNED: 1  
HOWARD
Item #: 105
UMC 2021  Section: Table 1210.1

SUBMITTER: Lance MacNevin, P.Eng.
Plastics Pipe Institute

RECOMMENDATION:
Revise text

TABLE 1210.1
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

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

(portion of table not shown remains unchanged)

Note: ASTM F1055 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
ASTM F1055 electrofusion fittings are compatible with PEX tubing described in ASTM F876 and CSA B137.5 and should be added into the FITTING column for PEX tubing. The addition of F876 PEX tubing into ASTM F1055 was approved by the ASTM F17 Technical Committee in 2013, to attest to the compatibility of connections made between F876 PEX tubing and F1055 fittings. Connections between F876 PEX tubing and F1055 fittings must meet the same requirements as those between HDPE tubing and F1055 fittings. Although F1055 fittings produced of HDPE material should not be used for hydronic applications operating at temperatures above 140F, there are many hydronic applications, including low-temperature radiant heating and chilled water systems, for which F1055 fittings are very suitable for use with PEX tubing. F1055 fittings are already listed in Table 1210.1 for use with HDPE and PE-RT pipe and tubing, and also in Table E505.6.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 106
UMC 2021 Section: Table 1210.1, Table 1701.1

SUBMITTER: Lance MacNevin, P.Eng.
Plastics Pipe Institute

RECOMMENDATION:
Revise text

### TABLE 1210.1
**MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS**

<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, NSF 358-3</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

### TABLE 1701.1
**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 F3253-2017</td>
<td>Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems</td>
<td>Piping</td>
<td>Table 1210.1</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: ASTM F3253 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The ASTM F17 Technical Committee on Plastic Piping Systems recently published new standard specification F3253 "Standard Specification for Crosslinked Polyethylene (PEX) Tubing with Oxygen Barrier for Hot- and Cold-Water Hydronic Distribution Systems". This is a PEX System standard for tubing with an oxygen diffusion barrier, including requirements for the fittings for use with this tubing. While F3253 is very similar to ASTM F876 for tubing (same dimensions) and ASTM F877 for fittings (same fitting connection performance), it also includes performance requirements for the oxygen diffusion resistance of integrated EVOH barrier layers, which is not part of F876. This is an important feature for those hydronic systems which need an oxygen barrier on the PEX tubing. Oxygen barrier performance is based on the industry's long accepted norm of the German DIN 4726 standard. In addition to the same joint integrity requirements as ASTM F877 for the fittings, F3253 also includes a pull-out test requirement for the fittings. F3253 does not replace F876 or F877. It is an additional product standard to which products can be tested and listed.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 107

UMC 2021  Section: Table 1210.1, Table 1701.1, Table 1701.2

SUBMITTER: Mark Fasel
Viega LLC

RECOMMENDATION:
Revise text

TABLE 1210.1
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

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

Note: IAPMO PS 117 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAPMO PS 117-2017</td>
<td>Press and Nail Connections</td>
<td>Fittings</td>
</tr>
</tbody>
</table>

Note: IAPMO PS 117 (2012 version) was moved to Table 1701.2 Standards, Publications, Practices, and Guides (non-mandatory) in the 2018 code cycle because at the time it did not technically qualify as a consensus standard. PS 117 has since passed through the consensus process and has been republished as PS 117 2017 edition which meets the qualification of a consensus document. IAPMO PS 117-2017 editions Document Preface includes this note: (5) This Standard was developed in accordance with the principles of consensus, which is defined as substantial agreement; consensus
implies much more than a simple majority, but not necessarily unanimity. It is consistent with this definition that a member of the IAPMO Standards
Review Committee might not be in full agreement with all sections of this Standard. This Standard has multiple listees for Copper press fittings and is
widely recognized in the market place by AHJ’s and Installers alike. This Standard is also proposed to be added to Table 1701.1 Referenced
Standards.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 108
UMC 2021  Section: Table 1210.1, Table 1701.1

SUBMITTER: Lance MacNevin, P.Eng.
Plastics Pipe Institute

RECOMMENDATION:
Revise text

**TABLE 1210.1**
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PIPING/TUBING</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389, <a href="#">CSA B137.11</a>, NSF 358-2</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**TABLE 1701.1**
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>CSA B137.11-2017</td>
<td>Polypropylene (PP-R) Pipe and Fittings for Pressure Applications</td>
<td>Piping</td>
<td>Table 1210.1, 1211.10(1)</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**Note:** CSA B137.11 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

**SUBSTANTIATION:**
CSA B137.11 is the approved system standard for Polypropylene pressure pipe and fittings (systems), which is analogous to ASTM F2389, currently listed in Table 1210.1 for PP Pipe and Fittings. It is common to list the equivalent CSA pipe and fitting system standards with the analogous ASTM and other product standards. B137.11 is currently missing from the Table, so this change will improve the Table. This update to Table 1210.1 will complete the process of listing the equivalent CSA pipe and fitting system standards.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1211.0 Joints and Connections.

1211.2 Chlorinated Polyvinyl Chloride (CPVC) Pipe. Joints between chlorinated polyvinyl chloride (CPVC) pipe or 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 non-removable push fit fittings with an elastomeric o-ring that employ quick assembly push fit connectors shall be in accordance with ASSE 1061.

(remaining text unchanged)

1211.3 CPVC/AL/CPVC Plastic Pipe and Joints. Joints between chlorinated polyvinyl chloride/aluminum/ chlorinated polyvinyl chloride (CPVC/AL/CPVC) pipe or fittings shall be installed in accordance with one of the following methods:
(1) Mechanical joints shall include, but not be limited to, flanged and grooved fittings.

(remaining text unchanged)

SUBSTANTIATION:
The proposed modification will clarify that other mechanical joints may be included. Furthermore, the modification will correlate with the action taken by the USEHC Committee.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is unenforceable and may lead to misinterpretation of the sections.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:

HYDE: I believe that the USHGC and the UMC shall be consistent where applicable for those AHJs that adopt both codes.
Item #: 110

UMC 2021  Section: 1211.4, 1211.4(5)

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1211.0 Joints and Connections.

1211.4 Copper or Copper Alloy Pipe and Tubing. Joints between copper or copper alloy pipe, tubing, or fittings shall be installed in accordance with one of the following methods:

(1) – (4) (remaining text unchanged)

(5) Removable and nonremovable push fit 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. Pipe or tubing shall be cut square, chamfered, and reamed to full inside diameter. The tubing shall be fully inserted into the fitting, and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to ensure the tubing is inserted into the fitting and gripping mechanism has engaged on the pipe.

(6) – (7) (remaining text unchanged)

SUBSTANTIATION:
The proposed modification will provide consistency throughout the code in regard to copper or copper alloy material. Furthermore, the modification will correlate with the action taken by the USEHC Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
1211.2 Chlorinated Polyvinyl Chloride (CPVC) Pipe. (remaining text unchanged)

(1) (remaining text unchanged)

(2) Solvent cement joints for CPVC pipe and fittings shall be clean from dirt and moisture. Solvent cements in accordance with shall comply with ASTM F493, those requiring the use of a primer shall be orange in color. The primer shall be colored and shall comply with ASTM F656. A two-step method of joining pipe and fittings shall be made in accordance with ASTM D2855. Listed solvent cement yellow or red in color that complies with ASTM F493 and that does not require the use of primers, yellow or red in color, shall be permitted for pipe and fittings that comply with ASTM D2846, 1/2 of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, 1/2 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) (remaining text unchanged)

1211.12 Polyvinyl Chloride (PVC) Pipe. (remaining text unchanged)

(1) (remaining text unchanged)

(2) A two-step method of joining pipe and fittings shall be made in accordance with ASTM D2855. 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 that complies with ASTM F656. Primer shall be applied to the surface of the pipe and fitting is softened. Solvent cement that complies 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) (remaining text unchanged)

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D2855-2015</td>
<td>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>
<td>1211.2(2), 1211.12(2)</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)
Note: ASTM D2855 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
ASTM D2855 is the two step installation practice. ASTM D2855 is 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. ASTM D2855 now includes CPVC two step installation practice. The language could be cleaned up a bit in the section. ASTM D2855 is 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.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed standard ASTM D2855 contains sections that are not written in mandatory and enforceable language.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 112

UMC 2021 Section: 1211.14

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1211.0 Joints and Connections.

1211.14 Joints Between Various 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 1211.14.1 and Section 1211.14.2.

SUBSTANTIATION:
Existing word “various” to be replaced with “different” as that is the intended subject of this requirement. “Various” means anything and does not imply “different.” Furthermore, the modification will correlate with the action taken by the USEHC Committee

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is unnecessary as the term “various” already covers the intent of the section.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 113  
UMC 2021  Section: 1213.4

SUBMITTER: Lance MacNevin, P.Eng.  
Plastic Pipe Institute

RECOMMENDATION:  
Add new text

**1213.0 System Controls.**

**1213.4 Simultaneous Operation.** Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling.

SUBSTANTIATION:  
Simultaneous operation requirements must be added to Chapter 12 as system controls are used to ensure the safe operation of the heat source by preventing operation of the appliance when an unsafe condition is present. Continued appliance operation during an unsafe condition presents a life safety hazard and potential for property damage, and therefore must be avoided. Furthermore, the language in Section 1213.4 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  
AFFIRMATIVE: 25   NOT RETURNED: 1   HOWARD
Item #: 114

UMC 2021  Section: 1213.5

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Add new text

1213.0 System Controls.

1213.5 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.

SUBSTANTIATION:
Section 1213.5 is being added to address when temperature readings in a hydronic systems are required. Furthermore, the language will be consistent with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 115

UMC 2021  Section: 1214.4

SUBMITTER: Lance MacNevin, P.Eng.  
Plastic Pipe Institute

RECOMMENDATION:  
Revise text

1214.0 Pressure and Flow Controls.

1214.4 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 fluid 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 1202.0 to prevent contamination due to backflow.

SUBSTANTIATION:  
The term “water” to “fluid” in second paragraph for consistency throughout the code. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

1214.0 Pressure and Flow Controls.

1214.4 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 fluid 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 1202.0 to prevent contamination due to backflow.

COMMITTEE STATEMENT:  
This modification removes the term "fluid" as the term is not needed since "makeup feed line" already implies that fluid is being used.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 116

UMC 2021  Section: 1214.4

SUBMITTER: Lee H Stevens
LH Stevens Constructors LLC

RECOMMENDATION:
Revise text

1214.0 Pressure and Flow Controls.
1214.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the water content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.

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

A pressure-reducing valve shall be installed on a makeup water feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 1202.0 to prevent contamination due to backflow.

SUBSTANTIATION:
Homeowners insurance property losses for water damage (2011-2015) are the second most frequent loss category, and second costliest per claim. Water damage from a leaking hydronic system can include mold damage, structural damage, and may render a building temporarily uninhabitable or subject to freezing up with additional damage. An automatic feed valve will maintain water pressure in a hydronic system, but will also continually supply a breached system at a potentially high rate of flow. Particularly if a breach occurs while a structure is unattended, the potential exists for the consequent water damage to far exceed the actual damage to the hydronic system. As building codes and industry practices have evolved in recent decades, largely pushed by the mandates of energy codes, hydronic systems have become more susceptible to damage and leakage. 1. setback thermostats, along with houses being left unattended, increase the risk of freeze-thaw damage. 2. Cast iron boilers have largely been replaced by high-efficiency units with low-mass stainless steel heat exchangers, which are much more subject to corrosion damage due to water quality issues. 3. High efficiency in-floor radiant heating systems inherently have a greater vulnerability to physical damage, such as fastener penetration, than traditional baseboard systems. A code requirement to limit water release through an automatic feed valve would be a significant step towards addressing consequential damage.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed modification is overly restrictive and does not address temperature versus volume variations.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 117
UMC 2021 Section: 1214.4

SUBMITTER: Lee H Stevens
LH Stevens Constructors LLC

RECOMMENDATION: 
Revise text

1214.0 Pressure and Flow Controls.

1214.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the water content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.

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

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

    A pressure-reducing valve shall be installed on a makeup water feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 1202.0 to prevent contamination due to backflow.

SUBSTANTIATION:
Homeowners insurance property losses for water damage (2011-2015) are the second most frequent loss category, and second costliest per claim. Water damage from a leaking hydronic system can include mold damage, structural damage, and may render a building temporarily uninhabitable and or subject to freezing up with additional damage. An automatic feed valve will maintain water pressure in a hydronic system, but will also continually supply a breached system at a potentially high rate of flow. Particularly if a breach occurs while a structure is unattended, the potential exists for the consequent water damage to far exceed the actual damage to the hydronic system. As building codes and industry practices have evolved in recent decades, largely pushed by the mandates of energy codes, hydronic systems have become more susceptible to damage and leakage. 1. Setback thermostats, along with houses being left unattended, increase the risk of freeze-thaw damage. 2. Cast iron boilers have largely been replaced by high-efficiency units with low-mass stainless steel heat exchangers, which are much more subject to corrosion damage due to water quality issues. 3. High efficiency in-floor radiant heating systems inherently have a greater vulnerability to physical damage, such as fastener penetration, than traditional baseboard systems. A code requirement to limit water release through an automatic feed valve would be a significant step towards addressing consequential damage. This proposal also specifically addresses the trade practice of use of a system feeder, in lieu of an automatic feed valve, for the purpose of limiting water release. A release volume limit as a percentage of total system volume has the intent to address and allow for the usual losses of larger volume systems.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

1214.0 Pressure and Flow Controls.

1214.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the water fluid content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.

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

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

    A pressure-reducing valve shall be installed on a makeup water feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 1202.0 to prevent contamination due to backflow.
COMMITTEE STATEMENT:
The proposed modification adds changes accepted in Item #115. Furthermore, Item #117 is being accepted in favor of Item #116 as this change applies to water in large and small systems.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:

MACNEVIN: I am concerned that the technology that could be used to satisfy the new language is not readily available in the hydronic market.
Item #: 118

UMC 2021  Section: 1214.5

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1214.0 Pressure and Flow Controls.

1214.5 Differential Pressure Regulation. Provisions shall be made to control 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.

SUBSTANTIATION:
The proposed language makes it more obvious as to the purpose of the differential pressure regulation device. The existing term "control" is too vague so the proposed language is more descriptive. The term "excessive" is clarified with the new language after "zone flows". The terms circulator and pump are somewhat synonymous, though different manufacturers apply these terms to devices of various sizes in an inconsistent manner. In other words, what one manufactures might call a "pump" another calls a circulator. Proposed language is inclusive of both terms to prevent confusion about which devices are covered by this section. Furthermore, the will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED:  1  HOWARD
Item #: 119  
UMC 2021  Section: 1214.6, 1214.7  

SUBMITTER: Lance MacNevin, P.Eng.  
Plastic Pipe Institute  

RECOMMENDATION:  
Revise text  

1214.0 Pressure and Flow Controls.  

1214.6 Air-Removal Device. Provision shall be made for the removal of air in the heat-distribution piping system 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.  

1214.7 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 distribution hydronic system.  

SUBSTANTIATION:  
The proposed modification clarifies that the air-separation device are required for hydronic systems. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.  

COMMITTEE ACTION: ACCEPT AS SUBMITTED  

TOTAL ELIGIBLE TO VOTE: 26  
VOTING RESULTS: AFFIRMATIVE: 25  
NOT RETURNED: 1  
HOWARD
Item #: 120

UMC 2021  Section: 1217.5.1 - 1217.5.4, 1217.6, 1220.2

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1217.0 Radiant Heating and Cooling.

1217.5 Poured Floor Structural Concrete Slab Systems (Thermal Mass). (remaining text unchanged)

1217.5.3 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.

(renumber remaining sections)

1217.5.4 1217.6 Joist Systems and Subfloors. (remaining text unchanged)

1217.6.1 Tubing Fasteners. Tubing that is installed within joist spaces and subfloor panel systems shall be fastened according to manufacturer's instructions. Unless prohibited by the manufacturer, tubing fasteners shall include the following:
(1) Heat transfer panel systems made of wood, aluminum or other thermally conductive materials intended for this application and the specific type of tube.
(2) Staples made of metal or plastic or combination thereof, without sharp edges that would harm tube, intended for this application and the specific type of tube fastened to subfloor.
(3) Plastic rails with integrated tube holders intended for the specific type of tube.
(4) Other fasteners recommended by the manufacturer.

1217.5.4 1217.7 Wall and Ceiling Panels. (remaining text unchanged)

1217.6 1217.9 Radiant Heating and Cooling Panels. (remaining text unchanged)

(renumber remaining sections)

1220.0 Auxiliary Systems.

1220.2 Types of Tube Fasteners. Tubing that is embedded within concrete shall be fastened according to manufacturer's instructions. Unless prohibited by the manufacturer, tube fasteners include the following:
(1) Ties made of wire, typically fastened to anchors such as rebar or wire mesh.
(2) Plastic tube/cable ties, typically nylon, fastened to anchors such as rebar or wire mesh.
(3) Staples made of metal or plastic or combination thereof, without sharp edges that would harm tube, fastened to insulation or subfloor.
(4) Plastic rails with integrated tube holders intended for the specific type of tube.
(5) Insulation sheets with integrated knobs for holding the specific type of tube and intended for this application.
(6) Other fasteners recommended by the manufacturer.
SUBSTANTIATION:
The new sections provides missing guidance to installers and inspectors about approved type of tube fasteners. The specific language was reached through consensus with the CSA B214 technical committee and will be in the next edition of CSA B214. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED
TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 26
Item #: 121

UMC 2021  Section: 1217.5.2, 1220.2.5

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1217.0 Radiant Heating and Cooling.

1217.5 Poured Floor Structural Concrete Slab Systems (Thermal Mass). (remaining text unchanged)

1217.5.2 Insulation. Where a poured concrete radiant floor system is installed in contact with the soil, insulation approved 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.

1220.0 Auxiliary Systems.

1220.2 Snow and Ice Melt Controls. (remaining text unchanged)

1220.2.5 Insulation. Where a poured concrete snow melt 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 concrete and the compacted grade; and be extended as close as practical to the outside edges of the concrete; and be placed on vertical slab edges that are in contact with plants or landscaping.

SUBSTANTIATION:
This proposal ensures that only appropriate insulation materials for use on soils and under concrete will be used in snow and ice melt systems. It is more efficient and responsive to build these systems using higher R-values than 5, but the current language limits insulation to R-5. Proposal will correct this. It is impractical to require vertical insulation at all slab edges, especially those in contact with plants or landscaping. In such installations, fastening the insulation against the slab is often impossible. The insulation is exposed to the elements and will disintegrate, especially when hit with weed trimmers, for instance. The insulation is unsightly, as no one wants a strip of blue or pink board at the end of their driveway or sidewalk. Finally, in some cases it is beneficial to allow some edge heat loss to occur, to thaw the soil against the slab edge to allow for natural drainage. Frozen soil would not allow melted snow to pass through. For all these reasons, the last part of the final sentence should be deleted. Furthermore, the modification to Section 1217.5.2 and Section 1220.2.5 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

1217.5 Poured Floor Structural Concrete Slab Systems (Thermal Mass). (remaining text unchanged)

1217.5.2 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.

1220.2.5 Insulation. Where a poured concrete snow melt system is installed in contact with the soil, insulation recommended by the manufacturer for such application and with a minimum R value of 5 shall be placed between the concrete and the compacted grade; and be extended as close as practicable to the outside edges of the concrete.

COMMITTEE STATEMENT:
The term “compacted” is being added back to Section 1220.2.5 for clarity.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 122

UMC 2021  Section: 1217.5.4, 1220.3

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION: Add new text

1217.0 Radiant Heating and Cooling.

1217.5 Poured Floor Structural Concrete Slab Systems (Thermal Mass). (remaining text unchanged)

1217.5.4 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).

(renumber remaining sections)

1220.0 Auxiliary Systems.

1220.3 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).

SUBSTANTIATION: The new sections provides missing guidance to installers and inspectors about spacing of tube fasteners. The specific language was reached through consensus with the CSA B214 technical committee and will be in the next edition of B214. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 123

UMC 2021  Section: 1217.6

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1217.0 Radiant Heating and Cooling.

1217.6 Radiant Heating and Cooling Panels. Radiant heating and cooling panels shall be installed in accordance with the manufacturer’s installation instructions and shall be listed for the application.

SUBSTANTIATION:
Section 1217.6 is being revised as there are no “listing” programs for radiant panels, so this requirement must be deleted. Furthermore, the deletion of Section 1217.6 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 124

UMC 2021  Section: 1217.6.1

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Delete text without substitution

1217.0 Radiant Heating and Cooling.

1217.6.1 Electric Heating Panel Systems. Clearances for electric heating panels or between outlets, junction boxes, mounting luminaries, ventilating, or other openings shall comply with NFPA 70.

(renumber remaining sections)

SUBSTANTIATION:
Electric Heating Panel Systems are electrical resistance heating systems constructed of grids of wires. This chapter is about hydronic systems. Electrical systems are not in the scope, so this section should be deleted. Furthermore, the deletion of Section 1217.6.1 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion of text is being rejected as the language is needed for enforcement of the code with regards to electric heating panel systems.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

MACNEVIN: The proposal is to remove this section which applies only to electric radiant systems, and is clearly outside the scope of a hydronics chapter.
Item #: 125

UMC 2021  Section: 1220.0, 1220.2.6

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1220.0 Auxiliary-Snow and Ice Melt Systems.

1220.2.6 Testing and Flushing. Testing and flushing of snow and ice melt auxiliary systems shall be in accordance with Section 1205.02 and flushing shall be in accordance with Section 1205.3.

SUBSTANTIATION:
Propose to add flushing to this section as a reminder that flushing should be part of the process for every hydronic system. The term “auxiliary” is being revised to “snow and ice melt” systems for consistency with other changes. Furthermore, the modification to Section 1220.2.6 will correlate with the action taken by the USEHC Technical Committee. The term “snow and ice melt” is used throughout the UMC.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 26
Item #: 126
UMC 2021  Section: 1220.1

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Delete text without substitution

1220.0 Auxiliary Systems.
1220.1 Use of Chemical Additives and Corrosive Fluids. Where auxiliary systems contain chemical additives, corrosive fluids, or both not intended or designed for use in the primary system, a double wall heat exchanger shall be used in accordance with Section 1218.1. The chemical additives in the auxiliary systems shall be compatible with auxiliary system components and accepted for use by the heat exchanger manufacturer.

(renumber remaining sections)

SUBSTANTIATION:
Requirements for heat exchangers and protecting potable water are already addressed in various sections of this Code, including Section 313.1 (General) as well as the plumbing codes. The proposal is to delete Section 416.2, as its contents are redundant and potentially confusing. Furthermore, the deletion of Section 1220.1 will correlate with the action taken by the USEHC Technical Committee. The title is being revise to “snow melt” to be consistent with technology used throughout the code.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is being rejected as the language is needed for enforcement of the code. Furthermore, removing the language from the code would create safety concerns.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 127
UMC 2021 Section: 1220.2

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1220.0 Auxiliary Systems.

1220.2 Snow and Ice Melt Controls. An automatic thermostatically operating control device that controls the supply hydronic solution fluid temperature to the snow and ice melt area shall be installed in the system. A means shall be provided to prevent low return hydronic fluid temperature in accordance with Section 1201.5. 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.

SUBSTANTIATION:
The term “solution” has been changed to “fluid” for consistency with other sections. The reference to ethylene glycol is being removed as the use of ethylene glycol is highly regulated by local jurisdictions for health and safety reasons. Lastly, the modification to Section 1220.2 will correlate with the action taken by the USEHC Technical Committee. The title is being revise to “snow melt” to be consistent with technology used throughout the code.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is not necessary and the current language is needed for enforcement of the code by the AHJ.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:
MACNEVIN: The proposed language would improve the code by protecting boilers against low return temperatures, allowing electronic mixing valves, and eliminating toxic ethylene glycol.
Item #: 128  
UMC 2021  Section: 1220.2.1  

SUBMITTER: Lance MacNevin, P.Eng.  
Plastic Pipe Institute  

RECOMMENDATION:  
Revise text  

**1220.0 Auxiliary Systems.**  

**1220.2.1 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. 

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 1220.2.1. Actual loop lengths shall be determined by spacing, flow rate, and pressure drop in accordance with the system design. 

SUBSTANTIATION:  
The term “spacing” was added to provide clarity as this specific provision is proving spacing requirements and it is already stated earlier in the same section. Lastly, the modification to Section 1220.2.1 will correlate with the action taken by the USEHC Technical Committee. The title is being revise to “snow melt” to be consistent with technology used throughout the code.  

COMMITTEE ACTION: ACCEPT AS SUBMITTED  

TOTAL ELIGIBLE TO VOTE: 26  

VOTING RESULTS:  
AFFIRMATIVE: 25  
NOT RETURNED: 1  
HOWARD
Item #: 129

UMC 2021  Section: 1220.2.2

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1220.0 Auxiliary Systems.

1220.2.2 Poured Structural Concrete Slab Systems (Thermal Mass). 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 surface of the finished concrete slab.

SUBSTANTIATION:
The term “thermal mass” can be confusing without a definition and does not change that this section is about poured concrete slabs, whose primary purpose is as the floor structure, so it should be deleted. The allowance of tubing to be within three pipe diameters of each other allows ½” nominal tubing to be at 1.88 inches on center, an extremely tight and problematic spacing for both the concrete strength and the tubing. An exception is added for tubing near the manifold, as tubing connections at manifolds are general at 2 inch on center, so that in the floor nearest the manifold the spacing must be tight. The “10 foot” exception is necessary for the tubes to spread out as they leave the manifold area. Language was added to the last sentence to improve clarity of the surface that is referred. Lastly, the modification to Section 1220.2.2 will correlate with the action taken by the USEHC Technical Committee. The title is being revise to “snow melt” to be consistent with technology used throughout the code.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 130

UMC 2021  Section: 1220.2.3

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1220.0 Auxiliary Systems.

1220.2.3 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 recommended by the tubing manufacturer. The space between the tubing and sleeve shall be sealed with an approved 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.

SUBSTANTIATION:
The proposed modification clarifies that the protective sleeving and sealant need to be recommended by the tubing manufacturer for the specific purpose. Furthermore, the word “approved” is used out of context, it should be changed to “recommend.” The term “approved” is a defined term within Chapter 2 as “acceptable to the Authority Having Jurisdiction.” By maintaining the term, it would imply that the AHJ has the responsibility to determine products compatibility as well as is intended purpose. This could lead to misapplication and confusion where on AJJ may permit a product and another AHJ may not permit the same product. It should be the manufacturer of the product who determines the intended use of the product. The manufacturer should identify the product’s intended application as well as describe within the manufacturer’s installation instructions how and where the product is to be installed. Lastly, the modification to Section 1220.2.3 will correlate with the action taken by the USEHC Technical Committee. The title is being revised to “snow melt” to be consistent with technology used throughout the code.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The word “recommended” is not enforceable by the AHJ.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

MACNEVIN: The existing language is not consistent with the meaning of the term “approved”, as per Chapter 2. The proposed change uses the preferred term “recommended.”
Item #: 131
UMC 2021  Section: 1220.2.4

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION: Delete text without substitution

1220.0 Auxiliary Systems.

1220.2.4 Concrete Slab Preparation. A solid foundation shall be prepared before the tubing is installed. Compaction shall be used for slabs, sidewalks, and driveways.

(renumber remaining sections)

SUBSTANTIATION:
This existing section has no requirements for hydronic components, only for concrete work, which is not the scope of this code or of hydronic installers. Section 1220.2.4 should be deleted. Furthermore, the deletion of Section 1220.2.4 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion of text is being rejected as the language is needed for enforcement of the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:

MACNEVIN: Section 1220.2.4 contains requirements for foundations for slabs, which is outside the scope of the UMC.
Item #: 132
UMC 2021  Section: 1220.3

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Delete text without substitution

1220.0 Auxiliary Systems.

1220.3 Hydronic Makeup-Air-Units. Hydronic makeup-air-units that are affected by freezing shall be protected against freezing by a hydronic solution.

SUBSTANTIATION:
Section 1220.3 is being deleted as it is not appropriate under “Auxiliary Systems.” Furthermore, the deletion for Section 1220.3 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion of text is being rejected as the language is needed for enforcement of the code.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 23  NEGATIVE: 1  ABSTAIN: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
HYDE: I believe that the USHGC and the UMC shall be consistent where applicable for those AHJs that adopt both codes.

EXPLANATION OF ABSTAIN:
MACNEVIN: This section is no longer relevant in this section and is redundant with another section.
Item #: 133
UMC 2021  Section: 1221.2

SUBMITTER: Lance MacNevin
Plastics Pipe Institute

RECOMMENDATION:
Revise text

1221.0 Piping Installation.

1221.2 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 the requirements of Section 1221.2.1 through Section 1221.2.3.

SUBSTANTIATION:
A pressure rating of 100 psi at 180°F is not necessary for hydronic applications, particularly when the tubing is embedded in concrete. Hydronic heating systems are typically designed with operating pressures of 12 psi to 20 psi; hydronic expansion tanks are typically factory set to 12 psi. Further, safety relief valves on hot-water boilers are typically set at 30 psi or 50 psi. Using any pipe or tubing embedded in concrete to convey 180°F fluid is likely to chemically and structurally damage the concrete, since most concrete mixes are rated for exposure to embedded pipes not higher than 140°F. So the pressure and temperature required in 1221.2 are extraordinary. PE-RT tubing listed in Table 1210.1 for HYDRONIC applications is in compliance with ASTM Standard F2623, "Standard Specification for Polyethylene of Raised Temperature (PE-RT) SDR 9 Tubing" which requires a pressure rating of 80 psi at 180°F (551 kPa at 82°C). This proposed change would update section 1221.2 to match the requirements of the products which are permitted to be installed in this manner.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 134

UMC 2021  Section: 1221.2.3

SUBMITTER: Lance MacNevin, P.Eng.
Plastic Pipe Institute

RECOMMENDATION:
Revise text

1221.0 Piping Installation.

1221.2 Embedded Piping Materials and Joints. (remaining text unchanged)

1221.2.3 Plastics. Plastic pipe and tubing shall be installed in continuous lengths or shall be joined by heat fusion methods, solvent cement joints, or other approved fittings in accordance with Table 1210.1 and the manufacturer’s installation instructions.

SUBSTANTIATION:
Heat fusion is applicable only to certain materials such as PP, PE-RT, or PE. For common hydronic materials such as CPVC, PEX and PE-RT, the ability to use embedded fittings when necessary is important, as fittings might be required to repair pipe that was damaged during construction. Many fittings for plastic tubing have been approved for use in other codes for years, and have been successfully installed in embedded applications for decades. Manufacturers of CPVC, PEX and PE-RT tubing and fittings systems want the ability to recommend use of their fittings in limited embedded applications when necessary. Examples of such fittings are those covered by existing ASTM standards D2846, F877, F1807, F1960, F2080, F2159, F2434, and F2735. In fact, each of these fitting systems are already included in Table 408.1. When manufacturers approve the use of such fittings for embedded applications, this code should not prohibit that use. The added reference to Table 408.1 ensures that only approved fittings for each type of pipe or tubing are eligible for this type of installation. Please see PPI Position Paper on Installation of PEX Fittings Within and Under Concrete Slabs at this link: http://www.plasticpipe.org/pdf/position-paper-pex-fitting-locations.pdf and PPI Position Paper on Installation of CPVC Fittings Within and Under Concrete Slabs at this link: https://plasticpipe.org/pdf/position-paper-cpvc-fitting-locations.pdf Furthermore, the revision to Section 1221.2.3 will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is being rejected as the language would allow joints under slabs. The TC does not agree that joints can be under slab except for heat fusion methods.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF NEGATIVE:
MACNEVIN: The submitted language is technically appropriate and should be added to this section.
Item #: 135
UMC 2021  Section: 1221.2.3

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

RECOMMENDATION:
Revise text

1221.0 Piping Installation.

1221.2 Embedded Piping Materials and Joints. (remaining text unchanged)

1221.2.3 Plastics. Plastic Pipe and tubing shall be installed in continuous lengths or shall be joined by heat fusion or an approved joining method.

SUBSTANTIATION:
Not all embedded hydronic plastic piping can be joined by heat fusion methods, and mechanical or other means should at least be possible if approved by the AHJ. There are products that are used for this purpose, including pre-fab roll out systems.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change is being rejected as the language would allow joints under slabs. The TC does not agree that joints can be under slab except for heat fusion methods.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 24   NEGATIVE: 1   NOT RETURNED: 1   HOWARD

EXPLANATION OF NEGATIVE:
CUDAHY: There are suitable materials and joining methods besides heat fusion for this application.
Item #: 136

UMC 2021  Section: 1308.5.8.1

SUBMITTER: Mohamed Dano
Control Air Conditioning Corporation

RECOMMENDATION:
Revise text

1308.0 Gas Piping System Design, Materials, and Components.

1308.5.8 Metallic Piping Joints and Fittings. (remaining text unchanged)

1308.5.8.1 Pipe Copper, Copper Alloy, and Stainless Steel Tubing Joints. Pipe Copper, copper alloy, or stainless steel tubing joints shall be threaded, flanged, brazed, welded, or press-connect fittings made in accordance with CSA LC-4. The tubing shall be assembled with an approved fitting. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus. For stainless steel alloys, brazing alloys and fluxes shall be permitted to be used where approved by the manufacturer for use on stainless steel alloys.

SUBSTANTIATION:
Section 1308.5.8.1 is being revised for consistency throughout the code. This will provide consistency throughout the industry in regards to the joining of copper, copper alloy, and stainless steel materials used in fuel gas piping systems.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is being rejected based on the action taken on Item # 145.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
SUBMITTER: David Dias  
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

1308.0 Gas Piping System Design, Materials, and Components.

1308.5 Acceptable Piping Materials and Joining Methods. (remaining text unchanged)

1308.5.8 Metallic Piping Joints and Fittings. (remaining text unchanged)

1308.5.8.4 Metallic Pipe Fittings (including Valves, Strainers, Filters). Metallic pipe fittings shall comply with the following:
(1) Threaded fittings in sizes exceeding 4 inches (100 mm) shall not be used unless acceptable to the Authority Having Jurisdiction.
(2) Fittings used with steel, stainless steel, or wrought-iron pipe shall be steel, stainless steel, copper alloy, bronze, malleable iron, or cast-iron.
(3) – (8) (remaining text unchanged)

SUBSTANTIATION:
Section 1308.5.8.4 is being revised to include “stainless steel.” Stainless steel is a common used material in the fuel gas industry. Furthermore, this will be consistent with current industry standards.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Proposals

Item #: 138

UMC 2021 Section: 1310.1.3.2

SUBMITTER: Robert N. Torbin
OmegaFlex

RECOMMENDATION: Revise text

1310.0 Gas Piping Installation.

1310.1.3 Protection Against Corrosion. (remaining text unchanged)

1310.1.3.2 Underground Piping. Underground piping shall comply with one or more of the following unless approved technical justification is provided to demonstrate that protection is unnecessary:

(1) The piping shall be made of corrosion-resistant material that is suitable for the environment in which it will be installed.
(2) Pipe shall have a factory-applied, electrically insulating coating. Fittings and joints between sections of coated pipe shall be coated in accordance with the coating manufacturer’s instructions.
(3) The piping shall have a cathodic protection system installed, and the system shall be maintained in accordance with Section 1310.1.3.3 or Section 1310.1.3.6. [NFPA 54:7.1.3.2]
(4) The piping shall be installed within an encasement system listed for underground use or a non-metallic, watertight conduit.

SUBSTANTIATION: The IAPMO published an interim guide criteria for polyethylene sleeved CSST (IGC-201) in 2004 which was renewed in 2014. The IGC-201 is currently (2018) being converted to a full IAPMO Standard. The use of listed encasement systems (such as polyethylene sleeved CSST) has been included in the National Fuel Gas Code (NFPA 54) Section 7.1.6 since the 2012 edition, and was first included in the 2015 edition of the Uniform Plumbing Code and Uniform Mechanical Code. This type of product has been used underground without failure or damage for approximately 15 years. Use of pre-assembled encasement systems streamlines the installation of gas piping underground, and can be installed underground without joints where required. This will protect the underground piping from corrosion, and improve safety (no joints/potential leak sites) when installing such systems. The use of buried conduit is already permitted by Section 1310.1.6 “piping underground beneath buildings,” but needs to be added here as well for consistency.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT: The proposed change is being rejected as it would allow burial of steel pipe. Furthermore, the term “encasement” is vague and ambiguous which would create confusion.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 139

UMC 2021  Section: 1310.1.6, Table 1701.1

SUBMITTER: Robert Torbin
Omega Flex Inc.

RECOMMENDATION:
Revise text

1310.0 Gas Piping Installation.
1310.1 Piping Underground. (remaining text unchanged)

1310.1.6 Piping Underground Beneath Buildings. Where gas piping is installed underground beneath buildings, the piping shall be either of the following:
(1) Encased in an approved conduit designed to withstand the imposed loads and installed in accordance with Section 1310.1.6.1 or Section 1310.1.6.2.
(2) A piping/encasement system listed for installation beneath buildings. [NFPA 54:7.1.6]
(3) Polyethylene sleeved-corrugated stainless steel tubing compliant with the requirements of IAPMO IGC 201.

TABLE 1701.1
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>IAPMO IGC 201-2018</td>
<td>Polyethylene Sleeved-Corrugated Stainless Steel Tubing for Use in Fuel Gas Piping Systems</td>
<td>Fuel Gas</td>
<td>1310.1.6(3)</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: IAPMO IGC 201 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
PE sleeved CSST have been tested and installed for over 10 years and continue to be installed today. IGC 201 covers Polyethylene Sleeved-Corrugated Stainless Steel tubing (PE-CSST) for use in fuel gas piping systems in underground and underground beneath building applications. Reference to the proper standard for this product will ensure public health and safety by clearly identifying products that are approved for this application assisting to the installers, inspectors and other end users of the code.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed addition of Note (3) is being rejected as it would allow for direct burial of CSST.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1 HOWARD
1310.0 Gas Piping Installation.

1310.3 Concealed Piping in Buildings. (remaining text unchanged)

1310.3.1 Connections. Where gas piping is to be concealed, connections shall be of the following type:
(1) Pipe fittings, such as elbows, tees, couplings, and right/left nipple/couplings.
(2) Joining tubing by brazing (see Section 1308.5.8.2).
(3) Fittings listed for use in concealed spaces or that have been demonstrated to sustain, without leakage, forces due to temperature expansion or contraction, vibration, or fatigue based on their geographic location, application, or operation to CSA LC 1 or CSA LC 4.
(4) Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a right/left nipple/coupling.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
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<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>CSA LC 1-2016</td>
<td>Fuel Gas Piping Systems using Corrugated Stainless Steel Tubing (same as CSA 6.26)</td>
<td>Fuel Gas</td>
<td>1308.5.3.4, 1310.3.1(3)</td>
</tr>
<tr>
<td>CSA LC 4a-2013</td>
<td>Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems (same as CSA 6.32a)</td>
<td>Fuel Gas</td>
<td>1308.5.8.1, 1308.5.8.2, 1310.3.1(3)</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: CSA LC 1 and CSA LC 4a meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The current language has caused confusion of the fittings that are listed and approved for installation in concealed locations. The only fittings that are listed as such are included along with the standards they should be listed to. This language comes directly from NFPA 54 and provides a much clearer understanding for the building official what types of fitting shall be listed and to what standards they shall be listed to. The proposed language will remove confusion in the industry.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

1310.0 Gas Piping Installation.

1310.3 Concealed Piping in Buildings. (remaining text unchanged)
1310.3.1 Connections. Where gas piping is to be concealed, connections shall be of the following type:
(1) Pipe fittings, such as elbows, tees, couplings, and right/left nipple/couplings.
(2) Joining tubing by brazing (see Section 1308.5.8.2).
(3) Press-connect fittings listed to CSA LC 4.
(4) Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a right/left nipple/coupling.

TABLE 1701.1
REFERENCED STANDARDS

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<td>Fuel Gas</td>
<td>1308.5.8.1, 1308.5.8.2, 1310.3.1(3)</td>
</tr>
</tbody>
</table>

COMMITTEE STATEMENT:
The term "press-connect" is being added to clarify the type of fitting intended. Furthermore, CSA LC-1 is being removed as the standard does not apply for such application.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD

1310.0 Gas Piping Installation.

1310.3 Concealed Piping in Buildings. (remaining text unchanged)
1310.3.1 Connections. Where gas piping is to be concealed, connections shall be of the following type:
(1) Pipe fittings, such as elbows, tees, couplings, and right/left nipple/couplings.
(2) Joining tubing by brazing (see Section 1308.5.8.2).
(3) Press-connect fittings listed to CSA LC 4 for use in concealed spaces or that have been demonstrated to sustain, without leakage, forces due to temperature expansion or contraction, vibration, or fatigue based on their geographic location, application, or operation.
(4) Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a right/left nipple/coupling.

TCC ACTION: ACCEPT AS SUBMITTED

TCC STATEMENT: The language in UMC Item # 140, Section 1310.3.1(3) (Connections) is being revised to correlate with UPC Item # 152, Section 1210.3.1(3) (Connections). In order to correlate the language, the Technical Correlating Committee proposed the following modifications to the UMC:
Item #: 141
UMC 2021  Section: 1312.6

SUBMITTER: David Dias  
Sheet Metal Workers Local 104

RECOMMENDATION:  
Revise text

1312.0 Appliance Connections to Building Piping.

1312.6 Appliance Shutoff Valves and Connections. Each appliance connected to a piping system shall have an accessible, approved manual shutoff valve with a nondisplaceable valve member, or a listed gas convenience outlet. Appliance shutoff valves and convenience outlets shall serve a single appliance only. The shutoff valve shall be located within 6 feet (1829 mm) of the appliance it serves.

Where a connector is used, the valve shall be installed upstream of the connector. A union or flanged connection shall be provided downstream from the valve to permit removal of appliance controls. Appliance shutoff valves serving decorative appliances shall be permitted to be installed in fireplaces if listed for such use. [NFPA 54:9.6.5, 9.6.5.1(A)(B)]

Exceptions:
(1) Shutoff valves serving decorative appliances in a fireplace shall not be permitted to be accessibly located inside or under an appliance within the fireplace firebox except where such appliance is removed without removal of the shutoff valve is listed for such use.
(2) Shutoff valves shall be permitted to be accessibly located inside wall heaters and wall furnaces listed for recessed installation where necessary maintenance is performed without removal of the shutoff valve.

SUBSTANTIATION:  
The appliance shutoff valve requirements are being revised to clarify that the exception applies to shutoff valves installed within the fireplace firebox unless listed for such use. Furthermore, this will be consistent with current industry standards.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  
AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 142
UMC 2021  Section: 1312.6

SUBMITTER: Paul Cabot
American Gas Association

RECOMMENDATION:
Revise text

1312.0 Appliance Connections to Building Piping.

1312.6 Appliance Shutoff Valves and Connections. Each appliance connected to a piping system shall have an accessible, approved manual shutoff valve with a nondisplaceable valve member, or a listed gas convenience outlet. Appliance shutoff valves and convenience outlets shall serve a single appliance only. The shutoff valve shall be located within 6 feet (1829 mm) of the appliance it serves. Where a connector is used, the valve shall be installed upstream of the connector. A union or flanged connection shall be provided downstream from the valve to permit removal of appliance controls. Shutoff valves serving decorative appliances shall be permitted to be installed in fireplaces if listed for such use. [NFPA 54:9.6.5, 9.6.5.1(A)(B)]

Exceptions:
(1) Shutoff valves shall be permitted to be accessibly located inside or under an appliance where such appliance is removed without removal of the shutoff valve.
(2) Shutoff valves shall be permitted to be accessibly located inside wall heaters and wall furnaces listed for recessed installation where necessary maintenance is performed without removal of the shutoff valve.
(3) Where installed at a manifold, the appliance shutoff valve shall be located within 6 feet (1829 mm) of the appliance served and shall be readily accessible and permanently identified. The piping from the manifold to within 6 feet (1829 mm) of the appliance shall be designed, sized, installed, and tested in accordance with Chapter 12. [NFPA 54:9.6.5.3]

SUBSTANTIATION:
The UPC does not contain the option that allows shutoff valves to be located at a manifold up to 50 ft away from the appliance it serves. The proposed text is taken from the 2018 National Fuel Gas Code. This option is a long standing option in the NFGC and does not prohibit the installation of a shutoff valve near the appliance if the installer wishes to do so for convenience of testing or service.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is being rejected as it allows a valve to be installed near a fireplace. Furthermore, it would conflict with Section 1312.6 in regards to the piping within 6 feet of the appliance.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 143

UMC 2021  Section: 1313.3

SUBMITTER: Paul Cabot
American Gas Association

RECOMMENDATION:
Revise text

1313.0 Pressure Testing and Inspection.

1313.3 Test Pressure. The necessary apparatus for conducting pressure tests shall be furnished by the permit holder. Test gauges used in conducting pressure tests shall be in accordance with Section 318.0. This inspection shall include an air, CO₂, or nitrogen pressure test in the presence of the Authority Having Jurisdiction, at which time the gas piping shall stand a pressure of in accordance with Section 1313.3.1 or Section 1313.3.2.

1313.3.1 Pressure Limits. The test pressure to be used shall be no less than 1½ times the proposed maximum working pressure, but not less than 3 psi (21 kPa), irrespective of design pressure. Where the test pressure exceeds 125 psi (862 kPa), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe. [NFPA 54: 8.1.4.2]

1313.3.2 Elevated Pressure Test. Where the Authority Having Jurisdiction requires an elevated pressure test, the pressure shall be not less than 10 psi (69 kPa) gauge pressure. Test pressures shall be held for a length of time satisfactory to the Authority Having Jurisdiction but in no case less than 15 minutes with no perceptible drop in pressure. For welded piping, and for piping carrying gas at pressures in excess of 14 inches water column pressure (3.5 kPa), the test pressure shall be not less than 60 psi (414 kPa) and shall be continued for a length of time satisfactory to the Authority Having Jurisdiction, but in no case for less than 30 minutes. For CSST carrying gas pressures in excess of 14 inches water column (3.5 kPa) pressure, the test pressure shall be not less than 30 psi (207 kPa) for 30 minutes. These tests shall be made using air, CO₂, or nitrogen pressure and shall be made in the presence of the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder. Test gauges used in conducting tests shall be in accordance with Section 318.0.

SUBSTANTIATION:
The proposal would permit the use of the pressure test criteria contain in the 2018 National Fuel Gas Code while continuing to allow the current UPC pressure test criteria when it is determined by the AHJ that an elevated pressure test is need for a particular piping installation. The NFGC test criteria has been successfully used for over 40 years and is widely used in the U.S.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is being rejected as this would reduce the test pressure requirements and will cause confusion in regards to enforcement of pressure testing and inspection.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Figure 1315.1.1
Example Illustrating Use of Table 1308.4.1 and Table 1315.2(1)

Problem: Determine the required pipe size of each section and outlet of the piping system shown in Figure 1315.1.1. Gas to be used has a specific gravity of 0.60 and 1100 British thermal units (Btu) per cubic foot (0.0114 kW•h/L), delivered at 8 inch water column (1.9 kPa) pressure.

(portion of figure not shown remains unchanged)

Solution:

(1) through (3) remain unchanged
(4) Using the column marked 60 feet (18 288 mm) in Table 1315.2(1) [no column for actual length of 55 feet (16 764 mm)]:
   Outlet B supplying 3 cubic feet per hour (0.08 m$^3$/h), requires $\frac{1}{2}$ of an inch (15 mm) pipe.
   Outlet C, supplying 59 cubic feet per hour (1.67 m$^3$/h), requires $\frac{1}{2}$ of an inch (15 mm) pipe.

(5) remains unchanged

Substantiation:
Section 1315.1.1 (Longest Length Method) makes reference the example above for the "longest length method." The proposed modification will remove language that makes a comment for the "branch length method." This proposed change will remove confusion when referencing, and illustrating a sample for the "longest length method."

Committee Action: Accept as Submitted

Total Eligible to Vote: 26

Voting Results: Affirmative: 25  Not Returned: 1  Howard
1302.0 Coverage of Piping System.

1302.3 Applications. This code shall not apply to the following items (reference standards for some of which appear in Chapter 47):

1. Portable LP-Gas appliances and equipment of all types that are not connected to a fixed fuel piping system.
2. Installation of appliances such as brooders, dehydrators, dryers, and irrigation equipment used for agricultural purposes.
3. Raw material (feedstock) applications except for piping to special atmosphere generators.
4. Oxygen-fuel gas cutting and welding systems.
5. Industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen, and nitrogen.
6. Petroleum refineries, pipeline compressor or pumping stations, loading terminals, compounding plants, refinery tank farms, and natural gas processing plants.
7. Large integrated chemical plants or portions of such plants where flammable or combustible liquids or gases are produced by chemical reactions or used in chemical reactions.
8. LP-Gas installations at utility gas plants.
10. Fuel gas piping in electric utility power plants.
11. Proprietary items of equipment, apparatus, or instruments such as gas-generating sets, compressors, and calorimeters.
12. LP-Gas equipment for vaporization, gas mixing, and gas manufacturing.
13. LP-Gas piping for buildings under construction or renovations that is not to become part of the permanent building piping system—that is, temporary fixed piping for building heat.
15. Installation of LP-Gas and compressed natural gas (CNG) systems on vehicles.
16. Gas piping, meters, gas-pressure regulators, and other appurtenances used by the serving gas supplier in distribution of gas, other than undiluted LP-Gas.
17. Building design and construction, except as specified herein.
18. Fuel gas systems on recreational vehicles manufactured in accordance with NFPA 1192.
20. Construction of appliances. [NFPA 54:1.1.1.2]

1308.0 Gas Piping System Design, Materials, and Components.

1308.1 Addition to Existing System. When additional appliances are being connected to a gas piping system, the existing piping shall be checked to determine whether it has adequate capacity. If the capacity of the system is determined to be inadequate for the additional appliances, the existing system shall be enlarged as required, or separate gas piping of adequate capacity shall be provided. [NFPA 54:5.1.2—5.1.2.2]

1308.4 Sizing of Gas Piping Systems. Gas piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand and supply gas to each appliance inlet at not less than the minimum supply pressure required by the appliance. [NFPA 54:5.4.1]

1308.4.2 Sizing Methods. Gas piping shall be sized in accordance with one of the following:

1. Pipe sizing tables or sizing equations in this chapter.
Other approved engineering methods acceptable to the Authority Having Jurisdiction. Sizing tables included in a listed piping system manufacturer’s installation instructions. [NFPA 54:5.4.3]

1308.5.2.1 Steel, Stainless Steel, and Wrought Iron. Steel, stainless steel, and wrought-iron pipe shall be at least not less than standard weight (Schedule 40) and shall comply with the dimensional standards of ASME B36.10M and one of the following standards:
(1) ASME B36.10M ASTM A53
(2) ASTM A53 ASTM A106
(3) ASTM A106 ASTM A312 [NFPA 54:5.6.2.2]

1308.5.3 Metallic Tubing. Seamless copper, aluminum alloy, or steel tubing shall not be used with gases corrosive to such tubing material. [NFPA 54:5.6.3.1]

1308.5.3.1 Stainless Steel. Stainless steel tubing shall comply with one of the following:
(1) ASTM A268
(2) ASTM A269 [NFPA 54:5.6.3.3]

1308.5.4 Plastic Pipe, Tubing, and Fittings. Polyethylene plastic pipe, tubing, and fittings used to supply fuel gas shall conform to ASTM D2513. Pipe to be used shall be marked “gas” and “ASTM D2513.” [NFPA 54:5.6.4.1.1] Polyamide pipe, tubing, and fittings shall be identified in and conform to ASTM F2945. Pipe to be used shall be marked “gas” and “ASTM F2945.” [NFPA 54:5.6.4.1.2] Polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) plastic pipe, tubing, and fittings shall not be used to supply fuel gas. [NFPA 54:5.6.4.1.3]

1308.5.6 Protective Coating. Where in contact with material or atmosphere exerting a corrosive action, metallic piping and fittings coated with a corrosion-resistant material shall be used. External or internal coatings or linings used on piping or components shall not be considered as adding strength. [NFPA 54:5.6.6]

1308.5.8.2 Tubing Pipe Joints. Tubing Schedule 40 and heavier pipe joints shall either be made threaded, flanged, brazed, welded, or assembled with approved gas tubing press-connect fittings, listed to ANSI CSA LC 4/CSA 6.32. (1) Pipe lighter than Schedule 40 shall be brazed with a material having a melting point in excess of 1000°F (538°C), or made by press-connect fittings in accordance with CSA LC-4. (2) Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.8.27.1]

1308.5.8.3 Copper Tubing Joints. Copper tubing joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1000°F (538°C), or shall be assembled with press-connect fittings listed to ANSI LC 4/CSA 6.32. Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.7.2]

1308.5.8.4 Stainless Steel Tubing Joints. Stainless steel joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1000°F (538°C), or assembled with press-connect fittings listed to ANSI LC 4/CSA 6.32. Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys and fluxes shall be recommended by the manufacturer for use on stainless steel alloys. [NFPA 54:5.6.7.3]

1308.8.3 Flared Joints. Flared joints shall be used in systems constructed from nonferrous pipe and tubing where experience or tests have demonstrated that the joint is approved suitable for the conditions and where provisions are made in the design to prevent separation of the joints. [NFPA 54:5.6.8.7.4]

1308.7 Gas Pressure Regulators. A line pressure regulator or gas appliance pressure regulator, as applicable, shall be installed where the gas supply pressure is higher than that at which the branch supply line or appliances are designed to operate or vary beyond design pressure limits exceeds the maximum allowable inlet pressure of the appliance served. [NFPA 54:5.8.1]

1308.7.1 Listing. Line pressure regulators shall be listed in accordance with CSA Z21.80 where the outlet pressure is set to 2 psi or less. [NFPA 54:5.8.2]

1308.7.6 Discharge of Vents. The discharge of vents shall be in accordance with the following:
(1) The discharge stacks, vents, or outlet parts of all pressure-relieving and pressure-limiting devices shall be located so that gas is safely discharged to the outdoors. (2) Discharge stacks or vents shall be designed to prevent the entry of water, insects, or other foreign material that could cause blockage. The discharge stack or vent line shall be at least the same size as the outlet of the pressure-relieving device. [NFPA 54:5.9.8.1, 5.9.8.2]
**1308.10 Overpressure Protection Devices.** Overpressure protection devices shall be one of the following:

1. Pressure relief valve.
3. Series regulator installed upstream from the line regulator and set to continuously limit the pressure on the inlet of the line regulator to the maximum values specified by Section 1308.9 or less.
4. Automatic shutoff device installed in series with the line pressure regulator and set to shut off when the pressure on the downstream piping system reaches the maximum values specified by Section 1308.9 or less. This device shall be designed so that it will remain closed until manually reset. [NFPA 54:5.9.3.1]

**1308.10.1 Separate Devices.** The devices in Section 1308.10 shall be installed either as an integral part of the service or line pressure regulator or as separate units. Where separate overpressure protection devices are installed, they shall comply with Section 1308.10.2 through Section 1308.10.7. [NFPA 54:5.9.3.2]

**1308.10.2 Construction and Installation.** All overpressure protection devices shall meet the following requirements:

1. Be constructed of materials so that the operation of the device is not impaired by corrosion of external parts by the atmosphere or of internal parts by the gas.
2. Be designed and installed so they can be operated to determine whether the valve is free. The devices shall also be designed and installed so they can be tested to determine the pressure at which they operate and be examined for leakage when in the closed position. [NFPA 54:5.9.4]

**1308.10.3 External Control Piping.** External control piping shall be designed and installed so that damage to the control piping of one device does not render both the regulator and the overpressure protective device inoperative. [NFPA 54:5.9.5]

**1308.10.4 Setting.** Each pressure limiting or pressure relieving device shall be set so that the gas pressure supplied to the connected appliance(s) does not exceed the limits specified in Section 1308.9 and Section 1308.9.1. [NFPA 54:5.9.6]

**1308.10.5 Unauthorized Operation.** Where unauthorized operation of any shutoff valve could render a pressure relieving valve or pressure limiting device inoperative, one of the following shall be accomplished:

1. The valve shall be locked in the open position. Instruct authorized personnel in the importance of leaving the shutoff valve open and of being present while the shutoff valve is closed so that it can be locked in the open position before leaving the premises.
2. Duplicate relief valves shall be installed, each having adequate capacity to protect the system, and arrange the isolating valves or three-way valve so that only one relief valve can be rendered inoperative at a time. [NFPA 54:5.9.7]

**1308.7.6 Discharge of Vents.** (remaining text unchanged)

**1308.10.7 Size of Fittings, Pipe, and Openings.** The fittings, pipe, and openings located between the system to be protected and the pressure relieving device shall be sized to prevent hammering of the valve and to prevent impairment of relief capacity. [NFPA 54:5.9.9]

(renumber remaining sections)

**1310.0 Gas Piping Installation.**

**1310.1 Piping Underground.** Underground gas piping shall be installed with approved sufficient clearance from any other underground structure to avoid contact therewith, to allow maintenance, and to protect against damage from proximity to other structures. In addition, underground plastic piping shall be installed with approved sufficient clearance or shall be insulated from any source of heat so as to prevent the heat from impairing the serviceability of the pipe. [NFPA 54:7.1.1]

**1310.2 CSST Piping Systems.** CSST piping systems shall be installed in accordance with this code and the manufacturer's installation instructions. [NFPA 54:7.1.8]

**1310.3 Installation of Piping.** (remaining text unchanged)

**1310.3.1 Protective Coating.** Where piping is in contact with a material or an atmosphere corrosive to the piping system, the piping and fittings shall be coated with a corrosion-resistant material. Any such coating used on piping or components shall not be considered as adding strength to the system. [NFPA 54:7.2.2]

(renumber remaining sections)

**1310.4 Hangers, Supports, and Anchors.** Piping shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers, or building structural components, approved suitable for the size of piping, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. Piping shall be anchored to prevent undue strains on connected appliances and equipment and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of MSS SP-58. [NFPA 54:7.2.86.1]

**1310.5 Maximum Design Operating Pressure.** The maximum design operating pressure for any piping systems located inside buildings shall not exceed 5 psi (34 kPa) unless one or more of the following conditions are met:

1. The piping is welded or brazed.
2. The piping joints are flanged and all pipe-to-flange connections are made by welding or brazing.
The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.

The piping is located inside buildings or separate areas of buildings used exclusively for one of the following:
(a) Industrial processing or heating
(b) Research
(c) Warehousing
(d) Boiler or mechanical rooms

The piping is a temporary installation for buildings under construction.

The piping serves appliances or equipment used for agricultural purposes.

The piping system is an LP-Gas piping system with an operating pressure greater than 20 psi (138 kPa) and complies with NFPA 58. [NFPA 54:5.5.4]

1310.10 Branch Pipe Connection. When a branch outlet is placed on a main supply line before it is known what size pipe will be connected to it, the outlet shall be of the same size as the line that supplies it. [NFPA 54:7.8]

1310.12 Prohibited Devices. No devices shall not be placed inside within the interior of gas piping or fittings that reduces where such devices reduce the cross-sectional area or otherwise obstructs the free flow of gas, except where proper allowance in the piping system design has been made for such a devices and where approved by the Authority Having Jurisdiction. [NFPA 54:7.409]

1311.0 Electrical Bonding and Grounding.

1311.2 Bonding of CSST Gas Piping. CSST gas piping systems, and gas piping systems containing one or more segments of CSST, shall be electrically continuous and bonded to the electrical service grounding electrode system or, where provided, lightning protection grounding electrode system. [NFPA 54:7.132.2]

1311.2.3 Bonding Jumper Length. The length of the jumper between the connection to the gas piping system and the grounding electrode system shall not exceed 75 feet (22 860 mm). Any additional grounding electrodes installed to meet this requirement shall be bonded to the electrical service grounding electrode system or, where provided, lightning protection grounding electrode system. [NFPA 54:7.132.2.3]

1311.3 Arc-Resistant Jacketed CSST. CSST listed with an arc-resistant jacket or coating system in accordance with ANSI LC 1/ CSA 6.26 shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST component of a piping system does not have an arc-resistant jacket or coating system, the bonding requirements of 1311.2 shall apply. Arc-resistant jacketed CSST shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.12.3]

(renumber remaining sections)

1312.0 Appliance Connections to Building Piping.

1312.1 Connecting Appliances and Equipment. Appliances and equipment shall be connected to the building piping in compliance with Section 1312.6 through Section 1312.8 by one of the following:
(1) - (4) (remaining text unchanged)
(5) CSST where installed in accordance with the manufacturer’s installation instructions. CSST shall connect only to appliances that are fixed in place.
(6) Listed nonmetallic gas hose connectors in accordance with Section 1312.3.
(7) Unlisted gas hose connectors for use in laboratories and educational facilities in accordance with Section 1212.4. [NFPA 54:9.6.1]

1312.9 Sediment Trap. Where a sediment trap is not incorporated as a part of the appliance, a sediment trap shall be installed downstream of the appliance shutoff valve as close to the inlet of the appliance as practical, but before the flex connector, where used at the time of appliance installation. The sediment trap shall be either a tee fitting with a capped nipple in the bottom outlet, as illustrated in Figure 1312.9, or other another device recognized as an effective sediment trap. Illuminating appliances, gas ranges, clothes dryers, decorative appliances for installation in vented fireplaces, gas fireplaces, and outdoor grills cooking appliances shall not be required to be so equipped. [NFPA 54:9.6.8]

1313.0 Pressure Testing and Inspections.

1313.1.6 Test Medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas. Oxygen shall not be used as a test medium. [NFPA 54:8.1.2]

1315.0 Required Gas Piping Size.

1315.2 Tables for Sizing Gas Piping Systems. Table 1315.2(1) through Table 1315.2(36) shall be used to size gas piping in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3. [NFPA 54:6.2]
1315.2 Sizing of Gas Piping Systems. Sizing of piping systems shall be in accordance with Section 1315.2.1 for natural gas piping system and Section 1315.2.2 for propane piping systems.

1315.2.1 Natural Gas Piping Systems. Table 1315.2(1) through Table 1315.2(23) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for piping materials other than non-corrugated stainless steel tubing. Section 1315.3 shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.2.1, 6.2.2]

1315.2.2 Propane Piping Systems. Table 1315.2(24) through Table 1315.2(36) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for piping materials other than non-corrugated stainless steel tubing. Section 1315.3 shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.3.1, 6.3.2]

1315.3 Sizing Equations. The inside diameter of smooth wall pipe or tubing shall be determined by Equation 1315.3(1), Equation 1315.3(2), Table 1315.3, and using the equivalent pipe length determined by the methods in Section 1315.1.1 through Section 1315.1.3. [NFPA 54:6.4]

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<th>TABLE 1315.2(15)</th>
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<td>CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2 TABLE 6.2.1(p)]¹,²</td>
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INTENDED USE: INITIAL SUPPLY PRESSURE OF 8.0 INCH WATER COLUMN OR GREATER

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¹ NFPA 54:6.2.1(p)
² NFPA 54:6.2.1
TABLE 1315.2(16)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2 TABLE 6.2.1(q)1, 2

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INTENDED USE: INITIAL SUPPLY PRESSURE OF 11.0 INCH WATER COLUMN OR GREATER

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TABLE 1701.1
REFERENCED STANDARDS

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<td>Welded and Seamless Wrought Steel Pipe</td>
<td>Fuel Gas Piping</td>
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<td>Piping, Ferrous</td>
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(portion of table not shown remains unchanged)

**Note:** ASME B36.10M, ASTM A53/A53M, ASTM A106/A106M, ASTM A312/A312M, ASTM A268, ASTM A269, ASTM F2945, CSA LC 1, CSA LC 4a, and NFPA 54/Z223.1 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

### 1302.0 Coverage of Piping System.

**1302.3 Applications.** This code shall not apply to the following items:

1. Portable LP-Gas appliances and equipment of all types that are not connected to a fixed fuel piping system.
2. Installation of appliances such as brooders, dehydrators, dryers, and irrigation equipment used for agricultural purposes.
3. Raw material (feedstock) applications except for piping to special atmosphere generators.
4. Oxygen–fuel gas cutting and welding systems.
5. Industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen, and nitrogen.
6. Petroleum refineries, pipeline compressor or pumping stations, loading terminals, compounding plants, refinery tank farms, and natural gas processing plants.
7. Large integrated chemical plants or portions of such plants where flammable or combustible liquids or gases are produced by chemical reactions or used in chemical reactions.
8. LP-Gas installations at utility gas plants.
10. Fuel gas piping in electric utility power plants.
11. Proprietary items of equipment, apparatus, or instruments such as gas-generating sets, compressors, and calorimeters.
12. LP-Gas equipment for vaporization, gas mixing, and gas manufacturing.
13. LP-Gas piping for buildings under construction or renovations that is not to become part of the permanent building piping system—that is, temporary fixed piping for building heat.
15. Installation of LP-Gas and compressed natural gas (CNG) systems on vehicles.
Gas piping, meters, gas-pressure regulators, and other appurtenances used by the serving gas supplier in distribution of gas, other than undiluted LP-Gas.

Building design and construction, except as specified herein.

Fuel gas systems on recreational vehicles manufactured in accordance with NFPA 1192.

Fuel gas systems using hydrogen as a fuel.

Construction of appliances. [NFPA 54:1.1.1.2]

1308.0 Gas Piping System Design, Materials, and Components.

1308.1.1 Addition to Existing System. When additional appliances are being connected to a gas piping system, the existing piping shall be checked to determine whether it has adequate capacity. If the capacity of the system is determined to be inadequate for the additional appliances, the existing system shall be enlarged as required, or separate gas piping of adequate capacity shall be provided. [NFPA 54:5.1.2]

1308.4 Sizing of Gas Piping Systems. Gas piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand and supply gas to each appliance inlet at not less than the minimum supply pressure required by the appliance. [NFPA 54:5.4.1]

1308.4.2 Sizing Methods. Gas piping shall be sized in accordance with one of the following:

1. Pipe sizing tables or sizing equations in this chapter.
2. Other approved engineering methods.
3. Sizing tables included in a listed piping system manufacturer’s installation instructions. [NFPA 54:5.4.3]

1308.5.2.1 Steel, Stainless Steel, and Wrought Iron. Steel, stainless steel, and wrought-iron pipe shall be at least Schedule 40 and shall comply with the dimensional standards of ASME B36.10M and one of the following:

1. ASTM A53
2. ASTM A106 [NFPA 54:5.6.2.2]
3. ASTM A312

1308.5.3 Metallic Tubing. Tubing shall not be used with gases corrosive to the tubing material. [NFPA 54:5.6.3.1]

1308.5.3.1 Stainless Steel. Stainless steel tubing shall comply with one of the following:

1. ASTM A268
2. ASTM A269 [NFPA 54:5.6.3.3]

1308.5.8.2 Pipe Joints. Schedule 40 and heavier pipe joints shall be threaded, flanged, brazed, welded, or assembled with press-connect fittings listed to ANSI CSA LC 4/CSCA 6.32.

1. Pipe lighter than Schedule 40 shall be connected using press-connect fittings, flanges, brazing, or welding.
2. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C).
3. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.7.1]

1308.5.8.3 Copper Tubing Joints. Copper tubing joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1000°F (538°C), or shall be assembled with press-connect fittings listed to ANSI LC 4/CSCA 6.32, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.7.2]

1308.5.8.4 Stainless Steel Tubing Joints. Stainless steel joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1000°F (538°C), or assembled with press-connect fittings listed to ANSI LC 4/CSCA 6.32, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys and fluxes shall be recommended by the manufacturer for use on stainless steel alloys. [NFPA 54:5.6.7.3]

1308.5.8.3 Flared Joints. Flared joints shall be used in systems constructed from nonferrous pipe and tubing where experience or tests have demonstrated that the joint is suitable for the conditions and where provisions are made in the design to prevent separation of the joints. [NFPA 54:5.6.7.4]
1308.7 Gas Pressure Regulators. A line pressure regulator shall be installed where the gas supply pressure exceeds the maximum allowable inlet pressure of the appliance served. [NFPA 54:5.8.1]

1308.7.1 Listing. Line pressure regulators shall be listed in accordance with CSA Z21.80 where the outlet pressure is set to 2 psi or less. [NFPA 54:5.8.2]

1308.7.6 Discharge of Vents. The discharge stacks, vents, or outlet parts of all pressure-relieving and pressure-limiting devices shall be located so that gas is safely discharged to the outdoors. Discharge stacks or vents shall be designed to prevent the entry of water, insects, or other foreign material that could cause blockage. The discharge stack or vent line shall be at least the same size as the outlet of the pressure-relieving device. [NFPA 54:5.9.8.1, 5.9.8.2]

1308.10 Overpressure Protection Devices. Overpressure protection devices shall be one of the following:

1. Pressure relief valve.
3. Series regulator installed upstream from the line regulator and set to continuously limit the pressure on the inlet of the line regulator to the maximum values specified by Section 1308.9 or less.
4. Automatic shutoff device installed in series with the line pressure regulator and set to shut off when the pressure on the downstream piping system reaches the maximum values specified by Section 1308.9 or less. This device shall be designed so that it will remain closed until manually reset. [NFPA 54:5.9.3.1]

1308.10.1 Separate Devices. The devices in Section 1308.10 shall be installed either as an integral part of the service or line pressure regulator or as separate units. Where separate overpressure protection devices are installed, they shall comply with Section 1308.10.2 through Section 1308.10.7. [NFPA 54:5.9.3.2]

1308.10.2 Construction and Installation. All overpressure protection devices shall meet the following requirements:

1. Be constructed of materials so that the operation of the device is not impaired by corrosion of external parts by the atmosphere or of internal parts by the gas.
2. Be designed and installed so they can be operated to determine whether the valve is free. The devices shall also be designed and installed so they can be tested to determine the pressure at which they operate and be examined for leakage when in the closed position. [NFPA 54:5.9.4]

1308.10.3 External Control Piping. External control piping shall be designed and installed so that damage to the control piping of one device does not render both the regulator and the overpressure protective device inoperative. [NFPA 54:5.9.5]

1308.10.4 Setting. Each pressure limiting or pressure relieving device shall be set so that the gas pressure supplied to the connected appliance(s) does not exceed the limits specified in Section 1308.9 and Section 1308.9.1. [NFPA 54:5.9.6]

1308.10.5 Unauthorized Operation. Where unauthorized operation of any shutoff valve could render a pressure relieving valve or pressure limiting device inoperative, one of the following shall be accomplished:

1. The valve shall be locked in the open position. Instruct authorized personnel in the importance of leaving the shutoff valve open and of being present while the shutoff valve is closed so that it can be locked in the open position before leaving the premises.
2. Duplicate relief valves shall be installed, each having adequate capacity to protect the system, and arrange the isolating valves or three-way valve so that only one relief valve can be rendered inoperative at a time. [NFPA 54:5.9.7]

1308.10.6 Discharge of Vents. (remaining text unchanged)

1308.10.7 Size of Fittings, Pipe, and Openings. The fittings, pipe, and openings located between the system to be protected and the pressure relieving device shall be sized to prevent hammering of the valve and to prevent impairment of relief capacity. [NFPA 54:5.9.9]

(renumber remaining sections)

1310.0 Gas Piping Installation.

1310.1 Piping Underground. Underground gas piping shall be installed with sufficient clearance from any other underground structure to avoid contact therewith, to allow maintenance, and to protect against damage from proximity to other structures. In addition, underground plastic piping shall be installed with sufficient clearance or shall be insulated from any source of heat so as to prevent the heat from impairing the serviceability of the pipe. [NFPA 54:7.1.1]

1310.2 CSST Piping Systems. CSST piping systems shall be installed in accordance with this code and the manufacturer's installation instructions. [NFPA 54:7.1.8]

1310.3 Installation of Piping. (remaining text unchanged)

1310.3.1 Protective Coating. Where piping is in contact with a material or an atmosphere corrosive to the piping system, the piping and fittings shall be coated with a corrosion-resistant material. Any such coating used on piping or components shall not be considered as adding strength to the system. [NFPA 54:7.2.2]

(renumber remaining sections)
1310.2.4 Hangers, Supports, and Anchors. Piping shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers, or building structural components, suitable for the size of piping, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. Piping shall be anchored to prevent undue strains on connected appliances and equipment and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of MSS SP-58. [NFPA 54:7.2.6.1]

1310.5 Maximum Design Operating Pressure. The maximum operating pressure for any piping systems located inside buildings shall not exceed 5 psi (34 kPa) unless one or more of the following conditions are met:
(1) The piping joints are welded or brazed.
(2) The piping joints are flanged and all pipe-to-flange connections are made by welding or brazing.
(3) The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
(4) The piping is located inside buildings or separate areas of buildings used exclusively for one of the following:
   (a) Industrial processing or heating
   (b) Research
   (c) Warehousing
   (d) Boiler or mechanical rooms
(5) The piping is a temporary installation for buildings under construction.
(6) The piping serves appliances or equipment used for agricultural purposes.
(7) The piping system is an LP-Gas piping system with an operating pressure greater than 20 psi (138 kPa) and complies with NFPA 58. [NFPA 54:5.5.4]

1310.12 Prohibited Devices. Devices shall not be placed within the interior of gas piping or fittings where such devices reduce the cross-sectional area or otherwise obstruct the free flow of gas, except where allowance in the piping system design has been made for such devices. [NFPA 54:7.9]

1311.0 Electrical Bonding and Grounding.

1311.2 Bonding of CSST Gas Piping. CSST gas piping systems, and gas piping systems containing one or more segments of CSST, shall be electrically continuous and bonded to the electrical service grounding electrode system or, where provided, lightning protection grounding electrode system. [NFPA 54:7.12.2]

1311.2.3 Bonding Jumper Length. The length of the jumper between the connection to the gas piping system and the grounding electrode system shall not exceed 75 feet (22 860 mm). Any additional grounding electrodes installed to meet this requirement shall be bonded to the electrical service grounding electrode system or, where provided, lightning protection grounding electrode system. [NFPA 54:7.12.2.3]

1311.3 Arc-Resistant Jacketed CSST. CSST listed with an arc-resistant jacket or coating system in accordance with ANSI LC 1/ CSA 6.26 shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST component of a piping system does not have an arc-resistant jacket or coating system, the bonding requirements of 1311.2 shall apply. Arc-resistant jacketed CSST shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.12.3]

(renumber remaining sections)

1312.0 Appliance Connections to Building Piping.

1312.1 Connecting Appliances and Equipment. Appliances and equipment shall be connected to the building piping in compliance with Section 1312.6 through Section 1312.8 by one of the following:
(1) - (4) (remaining text unchanged)
(5) CSST where installed in accordance with the manufacturer’s installation instructions. CSST shall connect only to appliances that are fixed in place.
(6) Listed nonmetallic gas hose connectors in accordance with Section 1312.3.
(7) Unlisted gas hose connectors for use in laboratories and educational facilities in accordance with Section 1212.4. [NFPA 54:9.6.1.1]

1312.9 Sediment Trap. Where a sediment trap is not incorporated as a part of the appliance, a sediment trap shall be installed downstream of the appliance shutoff valve as close to the inlet of the appliance as practical at the time of appliance installation. The sediment trap shall be either a tee fitting with a capped nipple in the bottom outlet, as illustrated in Figure 1312.9, or another device recognized as an effective sediment trap. Illuminating appliances, gas ranges, clothes dryers, decorative appliances for installation in vented fireplaces, gas fireplaces, and outdoor cooking appliances shall not be required to be so equipped. [NFPA 54:9.6.8]

1313.0 Pressure Testing and Inspections.
1313.1.6 Test Medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas. Oxygen shall not be used as a test medium. [NFPA 54:8.1.2]

1315.0 Required Gas Piping Size.

1315.2 Sizing of Gas Piping Systems. Sizing of piping systems shall be in accordance with Section 1315.2.1 for natural gas piping system and Section 1315.2.2 for propane piping systems.

1315.2.1 Natural Gas Piping Systems. Table 1315.2(1) through Table 1315.2(23) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for piping materials other than non-corrugated stainless steel tubing. Section 1315.3 shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.2.1, 6.2.2]

1315.2.2 Propane Piping Systems. Table 1315.2(24) through Table 1315.2(36) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for piping materials other than non-corrugated stainless steel tubing. Section 1315.3 shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.3.1, 6.3.2]

1315.3 Sizing Equations. The inside diameter of smooth wall pipe or tubing shall be determined by Equation 1315.3(1), Equation 1315.3(2), Table 1315.3, and using the equivalent pipe length determined by the methods in Section 1315.1.1 through Section 1315.1.3. [NFPA 54:6.4]

### TABLE 1315.2(15)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54:TABLE 6.2.1(p)]

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### TABLE 1315.2(16)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54:TABLE 6.2.1(q)]

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INTENDED USE: INITIAL SUPPLY PRESSURE OF 11.0 INCH WATER COLUMN OR GREATER

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(portion of table not shown remains unchanged)

### TABLE 1701.1
REFERENCED STANDARDS

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<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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<td>ASME B36.10M-2015</td>
<td>Welded and Seamless Wrought Steel Pipe</td>
<td>Fuel Gas Piping</td>
<td>1308.5.2.1</td>
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<td>ASTM A53/A53M-2012</td>
<td>Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless</td>
<td>Piping</td>
<td>1308.5.2.1(1), Table 1210.1, 1308.5.2.1</td>
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<td>ASTM A106/A106M-2015</td>
<td>Seamless Carbon Steel Pipe for High-Temperature Service</td>
<td>Piping</td>
<td>1308.5.2.1(2), Table 1210.1</td>
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<td>ASTM A312/A312M-2016a</td>
<td>Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</td>
<td>Piping, Ferrous</td>
<td>1308.5.2.1</td>
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ASTM A268/A268M-2010 (R2016) Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service Tubing 1308.5.3.1

ASTM A269/A269M-2015 Seamless and Welded Austenitic Stainless Steel Tubing for General Service Tubing 1308.5.3.1

ASTM F2945-2015 Polyamide 11 Gas Pressure Pipe, Tubing, and Fittings Tubing, Fittings 1308.5.4

CSA LC 1-2016 Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (same as CSA 6.26) Fuel Gas 1308.5.3.4, 1311.3

CSA LC 4a-2013 Press-Connect Metallic Fittings For Use in Fuel Gas Distribution Systems (same as CSA 6.32a) Fuel Gas 1308.5.8.1, 1308.5.8.2, 1308.5.8.3

NFPA 54/Z223.1-2015 National Fuel Gas Code Fuel Gas 516.2.1

COMMITTEE STATEMENT:
The modification adds back schedule 40 in favor of schedule 10 for steel pipe.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24 NEGATIVE: 1 NOT RETURNED: 1 HOWARD

EXPLANATION OF NEGATIVE:
WHITE: This item should be approved as submitted. Schedule 10 steel pipe has burst strength that exceeds other approved materials, offers reduction in material handling weights, and provides a viable option for installations.

1308.5.8.2 Pipe Joints. Schedule 40 and heavier pipe joints shall be threaded, flanged, brazed, welded, or assembled with press-connect fittings listed to ANSI CSA LC 4/CSA 6.32.

(1) Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C).

(2) Brazing alloys shall not contain more than 0.05 percent phosphorus.

1308.5.8.3 Copper Tubing Joints. Copper tubing joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1000°F (538°C), or shall be assembled with press-connect fittings listed to ANSI CSA LC 4/CSA 6.32, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.7.2]

1308.5.8.4 Stainless Steel Tubing Joints. Stainless steel joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1000°F (538°C), or assembled with press-connect fittings listed to ANSI CSA LC 4/CSA 6.32, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys and fluxes shall be recommended by the manufacturer for use on stainless steel alloys. [NFPA 54:5.6.7.3]

1311.3 Arc-Resistant Jacketed CSST. CSST listed with an arc-resistant jacket or coating system in accordance with ANSI CSA LC 1/CSA 6.26 shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST component of a piping system does not have an arc-resistant jacket or coating system, the bonding requirements of 1311.2 shall apply. Arc-resistant jacketed CSST shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.12.3]

TCC ACTION: ACCEPT AS SUBMITTED

TCC STATEMENT: The language in UMC Item # 145, Section 1308.5.8.2 (Pipe Joints), Section 1308.5.8.3 (Copper Tubing Joints), Section 1308.5.8.4 (Stainless Steel Tubing Joints), and Section 1311.3 (Arc-Resistant Jacketed CSST) are being revised to correlate with the language approved by the UPC TC Item # 157, Section 1211.3 (Arc-Resistant Jacketed CSST) with regards to the term ”ANSI” not being part of the standard
title as referenced throughout the UPC and UMC. Additionally, the references to "ANSI LC 1/CSA 6.26" and "ANSI LC 4/CSA 6.32" are being revised to correlate with the other references to similar standards in the UPC, UMC, and Table 1701.1. These CSA standards are referenced in Table 1701.1 and throughout the codes as “CSA LC 1” and “CSA LC 4.”

The action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for actions taken for Section 1308.5.8.2 (Pipe Joints), Section 1308.5.8.3 (Copper Tubing Joints), Section 1308.5.8.4 (Stainless Steel Tubing Joints), and Section 1311.3 (Arc-Resistant Jacketed CSST) with regard to the standard title reference within the codes.
Item #: 146
UMC 2021  Section: 1403.2

SUBMITTER: Reinhard Hanselka
Menlo Park Fire Protection District

RECOMMENDATION:
Add new text

1403.0 Plans Required.

1403.2 Technical Assistance. To determine the acceptability of technologies or processes, the design operation, or use subject to inspection by the Authority Having Jurisdiction, is authorized to require the owner or owner's authorized agent to provide, without charge to the jurisdiction, a technical opinion and report. The opinion and report shall be prepared by a qualified engineer, specialist, laboratory or fire safety specialty organization acceptable to the code official and shall analyze the design, operation or use of the facilities or appurtenances situated thereon, to recommend necessary changes. The Authority Having Jurisdiction is authorized to require design submittals to be prepared by and bear the stamp of a registered design professional.

SUBSTANTIATION:
The current trend in the acceptance of new and advanced technologies can put an undo burden on a code official. Jurisdictions cannot be assumed to have adequate staff to analyze and assess new technologies and methods. A similar provision which appears in the Uniform Fire Code has enabled Fire Code Officials to embrace and accept new technologies and methods.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is ambiguous and unenforceable.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 147
UMC 2021  Section: 1406.1, Table 1701.1

SUBMITTER: David Dias
Sheet Metal Workers Local 104

RECOMMENDATION:
Revise text

1406.0 Pipe, Tubing, and Fittings.

1406.1 General. Process pipe, tubing, and fittings shall comply with the applicable standards in Table 1701.1, ASME B31.3 and shall be installed in accordance with the manufacturer’s installation instructions. Materials shall be rated for the operating temperatures and pressures of the system, and shall be compatible with the type of liquid.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
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<tr>
<td>ASME B31.3-2016</td>
<td>Process Piping</td>
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<td>1406.1</td>
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(portions of table not shown remain unchanged)

Note: ASME B31.3 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
In the 2018 edition of the UMC, Table 1701.1 has been split into two separate tables. Therefore, the existing reference to those tables must be revised to provide the proper standard for the applications. ASME B31.3 is the proper standard for process piping that previously existed in Table 1701.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 148  
UMC 2021  Section: 1406.3.3  

SUBMITTER: Reinhard Hanselka  
Menlo Park Fire Protection District  
Rep: Fire Department  

RECOMMENDATION:  
Revise text  

1406.0 Pipe, Tubing, and Fittings.  

1406.3 Special Requirements for HPP Gases. (remaining text unchanged)  

1406.3.3 Gas Detection System. Where hazardous production material gas is used or dispensed and the physiological warning properties for the gas are at a higher level than the accepted permissible exposure limit for the gas, a continuous gas monitoring system shall be provided to detect the presence of a short-term hazard condition. Where dispensing occurs and flammable gases or vapors are capable of being present in quantities in excess of 20% 25 percent of the lower explosive limit, a continuous gas-monitoring system shall be provided. The monitoring system shall be connected to the emergency control station.  

SUBSTANTIATION:  
The level of monitoring to detect the presence of a flammable gas or vapor is monitored at 25% of the LEL in all other relevant codes: IBC, IFC, NFPA 1 etc. The UMC should be consistent with all others.  

COMMITTEE ACTION: ACCEPT AS SUBMITTED  

TOTAL ELIGIBLE TO VOTE: 26  

VOTING RESULTS:  
AFFIRMATIVE: 25  
NOT RETURNED: 1  
HOWARD
Item #: 149

UMC 2021  Section: Appendix B: B 104.1 - B 107.1

SUBMITTER: IAPMO Staff - Update Extracts
NFPA 54 Extract Update

RECOMMENDATION:
Revise text

B 101.0 Adjusting the Burner Input.
B 101.1 Adjusting Input. The input rate of the burner shall be adjusted to the proper value in accordance with the appliance manufacturer’s instructions. Firing at a rate in excess of the nameplate rating shall be prohibited. The input rate shall be adjusted by either changing the size of a fixed orifice, changing the adjustment of an adjustable orifice, or readjusting the appliance’s gas pressure regulator outlet pressure (where a regulator is provided in the appliance). [NFPA 54:11.1.1, 11.1.1.1]

B 104.0 Automatic Ignition.
B 104.1 General. Appliances supplied with means for automatic ignition shall be checked for operation within the parameters provided by the manufacturer. Any adjustments made shall be in accordance with the manufacturer’s installation instructions. [NFPA 54:11.4]

B 105.0 Protective Devices.
B 105.1 General. Where required by the manufacturer’s installation instructions, all protective devices furnished with the appliance such as a limit control, fan control to blower, temperature -and pressure -relief valve, low-water cutoff device, or manual operating features, shall be checked for operation within the parameters provided by the manufacturer. Any adjustments made shall be in accordance with the manufacturer’s installation instructions. [NFPA 54:11.5]

B 107.0 Operating Instructions.
B 107.1 General. Operating instructions shall be furnished and shall be left in a prominent position near the appliance for the use of by the consumer. [NFPA 54:11.7]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Section Appendix B is being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25    NOT RETURNED: 1    HOWARD
Item #: 150
UMC 2021 Section: D 105.0, D 105.1

SUBMITTER: Mohamed Dano
Control Air Conditioning Corporation

RECOMMENDATION:
Delete text without substitution

**D-105.0 Cathodic Protection Requirements.**

**D-105.1 General.** Cathodic protection shall be installed for corrosion control of buried or submerged metallic gas piping in accordance with the following requirements:

1. Where amphoteric metals are included in a buried or submerged pipeline containing a metal of different anodic potential the following protection shall be provided:
   
   (a) The buried or submerged pipeline shall be cathodically protected at a negative (cathodic) voltage of 0.85 volt, measured between the structure surface and a saturated copper-copper sulfate half cell contacting the electrolyte.
   
   (b) The amphoteric metals shall be electrically isolated from the remainder of the pipeline with insulating flanges, or equivalent, and cathodically protected.

2. The amount of cathodic protection shall be such that the protective coating and the pipe are not damaged.

SUBSTANTIATION:
Section D 105.0 and Section D 105.1 are being deleted as they conflict with the other cathodic protection sections that are already addressed within Appendix D. For example, Section D 110.2 and Section D 110.2.1 already provide cathodic protection provisions applicable to manufactured homes.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed deletion of text is being rejected as existing language covers different piping systems and the text is needed for enforcement of the code in regards to cathodic protection requirements.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 151

UMC 2021  Section: Appendix D: D 101.1 - D 115.3

SUBMITTER: IAPMO Staff - Update Extracts
NFPA 501A Extract Update

RECOMMENDATION:
Revise text

D 101.0 Fuel Gas Piping Systems.

D 101.1 General. All fuel gas piping systems serving manufactured homes, accessory buildings, or structures and communities shall be designed and constructed in accordance with the applicable provisions of NFPA 54 and NFPA 58. NFPA 31 shall apply to oil fuel-burning systems and shall conform to the criteria of the Authority Having Jurisdiction. [NFPA 501A:4.1.1.1 – 4.1.1.2]

D 101.2 Gas Supply Connections. Gas supply connections at sites, where provided from an underground gas supply piping system, shall be located and arranged to permit attachment to a manufactured home (M/H) occupying the site.

For the installation of liquefied petroleum gas (LPG) storage systems, the applicable provisions of NFPA 58 shall be followed. [NFPA 501A:4.1.2.1 – 4.1.2.2]

D 101.3 Location of Gas Supply Connection. The gas supply to the M/H manufactured home shall be located within 4 feet (1219 mm) of the M/H manufactured home stand.

Exception: The requirement of Section D 101.3 shall not apply to gas supply connections for manufactured homes located on all-weather wood, concrete, or concrete block foundation systems or on foundations constructed in accordance with the local building code or, in the absence of a local code, with a recognized model building code. [NFPA 501A:4.1.3]

D 102.0 Single and Multiple Manufactured Home Site Fuel Supply Systems.

D 102.1.1 Open-Ended Gastight Conduit. Underground gas piping shall not be installed beneath that portion of a M/H manufactured home site reserved for the location of a manufactured home or M/H manufactured home accessory building or structure unless installed in the open-ended gastight conduit of Section D 102.1.2. [NFPA 501A:4.2.1.1]

D 102.1.2 Requirements. The open-ended gastight conduit shall conform to the requirements in the following:
1. The conduit shall be not less than Schedule 40 pipe that is approved for underground installation beneath buildings.
2. The interior diameter of the conduit shall be not less than 1/2 of an inch (15 mm) larger than the outside diameter of the gas piping.
3. The conduit shall extend to a point not less than 4 inches (102 mm) beyond the outside wall of the M/H, manufactured home or accessory building, or structure, and the outer ends shall not be sealed.
4. Where the conduit terminates within a M/H, manufactured home or accessory building, or structure, it shall be accessible, and the space between the conduit and the gas piping shall be sealed to prevent leakage of gas into the building. [NFPA 501A:4.2.1.2 – 4.2.1.2.4]

D 103.0 Manufactured Home Site Gas Shutoff Valve.

D 103.1 General. Each M/H manufactured home site shall have a listed gas shutoff valve installed upstream of the M/H manufactured home site gas outlet. The gas shutoff valve shall be located on the outlet riser at a height of not less than 6 inches (152 mm) above grade. A gas shutoff valve shall not be located under a M/H any manufactured home. The outlet shall be equipped with a cap or plug to prevent discharge of gas whenever the M/H manufactured home site outlet is not connected to a M/H manufactured home. [NFPA 501A:4.2.2.1 – 4.2.2.4]
Exception: Gas shutoff valves shall conform to Section D 103.1, except for manufactured homes located on foundations constructed in accordance with the local building code or, in the absence of a local code, with a recognized model building code. [NFPA 501A:4.2.2.2]

D 104.0 Gas Meters.

D 104.1 Support of Meters. Where installed, gas meters shall be supported by a post or bracket placed on a firm footing or other means providing equivalent support and shall not depend on the gas outlet riser for support. [NFPA 501A:4.2.3.1]

D 104.2 Location of Meters. Each gas meter shall be installed in an accessible location and shall be provided with unions or other fittings so that the meter can be removed easily and replaced in an upright position. Meters shall not be installed in unventilated or inaccessible locations or closer than 3 feet (914 mm) to sources of ignition. [NFPA 501A:4.2.3.2.1 – 4.2.3.2.2]

D 104.3 Meter Shutoff Valve or Cock. All gas meter installations shall be provided with shutoff valves or cocks located adjacent to and on the inlet side of the meters. In the case of a single meter installation utilizing an LP-Gas container, the container service valve shall be permitted to be used in lieu of the shutoff valve or cock. All gas meter installations shall be provided with test tees located adjacent to and on the outlet side of the meters. [NFPA 501A:4.2.4.1 – 4.2.4.3]

D 106.0 Manufactured Home Community LPG Supply Systems.

D 106.1 General. Where 10 or more customers are served by one LP-Gas supply system, the installation of the gas supply system shall be in accordance with 49 CFR 192. Other types of liquefied petroleum gas supply systems and the storage and handling of LP-Gas shall be in accordance with NFPA 58. (see Section D113.0) [NFPA 501A:4.3.2.1 – 4.3.2.2]

D 107.0 Required Gas Supply.

D 107.1 General. The minimum hourly volume of gas required at each M/H manufactured home site outlet or any section of the M/H manufactured home community gas piping system shall be calculated as shown in Table D 107.1. [NFPA 501A:4.3.4.1]

In extreme climate areas, additional capacities other than those shown in Table D 107.1 shall be considered.

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<th>BRITISH THERMAL UNITS PER HOUR PER M/H SITE</th>
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D 108.0 Gas Pipe Sizing and Pressure.

D 108.2 Pressure. Where all connected appliances are operated at their rated capacity, the gas supply pressure shall be not less than 7 inches of water column (1.7 kPa). The gas supply pressure shall not exceed 14 inches of water column (3.5 kPa). [NFPA 501A:4.3.5.2]

D 109.0 Gas Piping Materials.

D 109.2 Protection Coatings for Metal Gas Piping. All B buried or submerged metallic gas piping shall be protected from corrosion by approved coatings or wrapping materials. All G gas pipe protective coatings shall be approved types, shall be machine applied, and shall comply with conform to recognized standards. Field wrapping shall provide equivalent protection and is restricted to those short sections and fittings that are necessarily stripped for threading or welding. Risers shall be coated or wrapped to a point not less than at least 6 inches (152 mm) above ground. [NFPA 501A:4.3.6.2 – 4.3.6.2.4]

D 110.0 Gas Piping Installations.

D 110.1 Minimum Burial Below Ground Level and Clearances. All G gas piping installed below ground level shall have an a minimum earth cover of not less than 18 inches (457 mm) and shall be installed with not less than at least 12 inches (305 mm) of clearance in any direction from any other underground utility systems. [NFPA 501A:4.3.7.1]

D 110.2 Metallic Gas Piping. All M metallic gas piping systems shall be installed in accordance with approved plans and specifications, construction documents, including provisions for cathodic protection. Each cathodic protection system shall be designed and installed to conform to in accordance with the provisions of 49 CFR 192. [NFPA 501A:4.3.7.2.1, 4.3.7.2.2]

D 110.2.1 Cathodic Protection. Where the cathodic protection system is designed to protect only the gas piping system, the gas piping system shall be electrically isolated from all other underground metallic systems or installations. Where only the gas piping system is cathodically protected against corrosion, a dielectric fitting shall be used in the M/H manufactured home gas connection to insulate the M/H manufactured home from the underground gas piping system. [NFPA 501A:4.3.7.2.3, 4.3.7.2.4]

D 110.2.2 Underground Metallic Systems. Where a cathodic protection system is designed to provide all underground metallic systems and installations with protection against corrosion, all such systems and installations shall be electrically bonded together and protected as a whole. [NFPA 501A:4.3.7.2.5]

D 110.3 Plastic Gas Piping. Plastic gas piping shall be used only underground and shall be installed with an electrically conductive wire for locating the pipe. The wire used to locate the plastic pipe shall be copper, not less smaller in size than No. 18 AWG, with insulation approved for direct burial. Every P portions of a plastic gas piping system consisting of metallic pipe shall be cathodically protected against corrosion. [NFPA 501A:4.3.7.3.1 – 4.3.7.3.3]

D 110.4 Gas Piping System Shutoff Valve. An accessible and identifiable shutoff valve controlling the flow of gas to the entire M/H manufactured home community gas piping system shall be installed in a location approved acceptable by to the Authority Having Jurisdiction and near the point of connection to the service piping or to the supply connection of an LP-Gas container. [NFPA 501A:4.3.7.4]

D 113.0 Fuel Supply Systems Installation.

D 113.2 Use of Approved Pipe and Fittings of Extension. Where it is necessary to extend the M/H a manufactured home inlet to permit connection of the 6 foot (1829 mm) listed connector to the site gas outlet, the extension shall be of approved materials of the same size as the M/H manufactured home inlet and shall be adequately supported at not no more than 4 foot (1219 mm) intervals to the M/H manufactured home. [NFPA 501A:4.4.2]

D 113.3 Mechanical Protection. All G gas outlet risers, regulators, meters, valves, or and other exposed equipment shall be protected against accidental damage. [NFPA 501A:4.4.3]
D 113.4 Special Rules on Atmospherically Controlled Regulators. Atmospherically controlled regulators shall be installed in such a manner that moisture cannot enter the regulator vent and accumulate above the diaphragm. Where the regulator vent is obstructed due to snow and icing conditions, shields, hoods, or other approved suitable devices shall be provided to guard against closing of the vent opening. [NFPA 501A:4.4.4.1 – 4.4.4.2]

D 113.5 Fuel Gas Piping Test. The M/H manufactured home fuel gas piping system shall be tested only with air before it is connected to the gas supply. The M/H manufactured home gas piping system shall be subjected to a pressure test with all appliance shutoff valves in their closed positions. [NFPA 501A:4.4.5]

D 113.5.1 Procedures. The fuel gas piping test shall consist of air pressure of at not less than 10 inches water column or more than 14 inches water column (2.5 kPa to 3.5 kPa). The fuel gas piping system shall be isolated from the air pressure source and shall maintain this pressure for not less than 10 minutes without perceptible leakage. Upon satisfactory completion of the fuel gas piping test, the appliance valves shall be opened; and the gas appliance connectors shall be tested with soapy water or bubble solution while under the pressure remaining in the piping system. Solutions used for testing for leakage shall not contain corrosive chemicals. Pressure shall be measured with either a manometer, slope gauge, or gauge that is calibrated in either water inch (mm) or psi (kPa), with increments of either $\frac{1}{10}$ of an inch (2.5 mm) or $\frac{1}{10}$ psi (0.7 kPa) gauge, as applicable. Upon satisfactory completion of the fuel gas piping test, the M/H manufactured home gas supply connector shall be installed and the connections shall be tested with soapy water or bubble solution. [NFPA 501A:4.4.6.1 – 4.4.5.1.6]

D 113.5.2 Warning. The following warning shall be supplied to the installer:

**WARNING**: Do not overpressurize the fuel gas piping system. Damage to valves, regulators, and appliances is capable of occurring due to pressurization beyond the maximums specified. [NFPA 501A:4.4.5.2]

D 113.5.3 Vents. Gas appliance vents shall be visually inspected to ensure that they have not been dislodged in transit and are connected securely to the appliance. [NFPA 501A:4.4.5.3]

D 113.6 Oil Tanks. **Oil tank capacities shall comply with the following**:

1. No more than one 660 gallon (2498 L) tank or two tanks with an aggregate capacity of 660 gallons (2498 L) or less shall be connected to one oil-burning appliance.

2. Two supply tanks, where used, shall be cross-connected and provided with a single fill and single vent, in accordance with as described in NFPA 31, and shall be on a common slab and rigidly secured, one to the other.

3. Tanks having a capacity of 600 gallons (2498 L) or less shall be securely supported by rigid, noncombustible supports to prevent settling, sliding, or lifting. [NFPA 501A:4.4.6]

D 113.6.1 Installation. Oil supply tanks shall be installed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.4.6.1]

D 113.6.2 Capacity. A tank with a capacity not no larger than 60 gallons (227 L) shall be permitted to be a DOT-5 shipping container (drum), and so marked, or a tank constructed in accordance with meeting the provisions of UL 80. Tanks other than DOT-5 shipping containers having a capacity of not more than 60 gallons (2498 L) shall be constructed in accordance with meet the provisions of UL 80. Pressure tanks shall be constructed built in accordance with Section VIII, Pressure Vessels, of the ASME Boiler and Pressure Vessel Code. [NFPA 501A:4.4.6.2.1 – 4.4.6.2.2]

D 113.6.3 Location. Tanks, as described in Section D 113.6 and Section D 113.6.2, that are adjacent to buildings shall be located not less than 10 feet (3048 mm) from a property line that is permitted to be built upon. [NFPA 501A:4.4.6.3]

D 113.6.4 Vent. Tanks with a capacity not no larger than 660 gallons (2498 L) shall be equipped with an open vent not no smaller than 1$\frac{1}{2}$ inch (40 mm) iron pipe size; tanks with a 500 gallon (1892 L) or less capacity shall have a vent of 1$\frac{1}{4}$ inch (32 mm) iron pipe size. [NFPA 501A:4.4.6.4]

D 114.0 Manufactured Home Accessory Building Fuel Supply Systems.

D 114.1 General. Fuel gas supply systems installed in a M/H manufactured home accessory building or structure shall be in accordance comply with the applicable provisions of NFPA 54 and NFPA 58. Fuel oil supply systems shall comply with the applicable provisions of NFPA 31. [NFPA 501A:4.5.1 – 4.5.2]

D 115.0 Community Building Fuel Supply Systems in Manufactured Home Communities.

D 115.1 Fuel Gas Piping and Equipment Installations. Fuel gas piping and equipment installed within a permanent building in a M/H manufactured home community shall be in accordance comply with nationally recognized appliance and fuel gas piping codes and standards adopted by the Authority Having Jurisdiction. Where the state or other political subdivision does not assume jurisdiction, such fuel gas piping and equipment installations shall be designed and installed in accordance with the applicable provisions of NFPA 54 or NFPA 58. [NFPA 501A:4.6.1.1 – 4.6.1.2]
D 115.2 Oil Supply Systems in M/H Manufactured Home Communities. Oil-burning equipment and installations within a M/H manufactured home community shall be designed and constructed in accordance with the applicable codes and standards adopted by the Authority Having Jurisdiction. Where the state or other political subdivision does not assume jurisdiction, such installations shall be designed and constructed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.6.2.1 – 4.6.2.2]

D 115.3 Oil-Burning Equipment and Installation. Oil-burning equipment and installations within a building constructed in a M/H manufactured home community in accordance with the local building code or a nationally recognized building code shall be in accordance comply with nationally recognized codes and standards adopted by the Authority Having Jurisdiction. Where the state or other political subdivision does not assume jurisdiction, such oil-burning equipment and installations shall be designed and installed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.6.3.1 – 4.6.3.2]

SUBSTANTIATION:

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
E 201.7 Integrated Part-Load Value (IPLV). A single-number figure of merit based on part-load EER, COPC, or kW/ton expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment. [ASHRAE 90.1:3.2]

E 503.3.1 Criteria. The HVAC system shall comply with the following criteria:

(1) - (10) (remaining text unchanged)

(11) Systems serving hotel/motel guest rooms shall comply with Section E 503.4.6.3.5.

(12) Except for piping within manufacturer’s units, HVAC piping shall be insulated in accordance with Table E 503.7.3(1) and Table E 503.7.3(2). Insulation exposed to weather shall be suitable for outdoor service, (e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover). Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation.

(13) Ductwork and plenums shall be insulated in accordance with Table E 503.7.2 and shall be sealed in accordance with Section E 503.4.7.2.

(14) Construction documents shall require a ducted system to be air balanced in accordance with industry-accepted procedures.

(15) Outdoor air intake and exhaust systems shall comply with Section E 503.4.6.4 through Section E 503.4.6.5.

(16) Where separate heating and cooling equipment serves the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

(17) Systems with a design supply air capacity more than 10,000 ft³/min (4.7195 m³/s) shall have optimum start controls.

(18) The system shall comply with the demand control ventilation requirements of Section E 503.4.6.9 and the ventilation design requirements of Section E 503.5.6.6.

(19) The system shall comply with the door switch requirements of Section E 503.5.14. [ASHRAE 90.1:6.3.2]

E 503.4 Mandatory Provisions. Equipment shown in Table E 503.7.1(1) through Table E 503.7.1(16) shall have a minimum performance at the specified rating conditions where tested in accordance with the specified test procedure. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy the stated requirements unless otherwise exempted by footnotes in the table. Equipment covered under the Federal Energy Policy Act of 1992 (EPACT) shall have no minimum efficiency requirements for operation at minimum capacity or other than standard rating conditions. Equipment used to provide service water-heating functions as part of a combination system shall satisfy the stated requirements for the appropriate space heating or cooling category.

Tables are as follows:

(1) Table E 503.7.1(1), “Electrically Operated Unitary Air Conditioners and Condensing Units-Minimum Efficiency Requirements”

(2) Table E 503.7.1 (2), “Electrically Operated Unitary and Applied Heat Pumps-Minimum Efficiency Requirements”

(3) Table E 503.7.1 (3), “Water-Chilling Packages-Efficiency Requirements” (See Section E 503.4.1 for water-cooled centrifugal water-chilling packages that are designed to operate at nonstandard conditions.)

(4) Table E 503.7.1 (4), “Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps-Minimum Efficiency Requirements”
All furnaces with input ratings of 225,000 Btu/h (66 kW) or more, including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating. Air conditioners primarily serving computer rooms and covered by ASHRAE 127 shall comply with the requirements in Table E 503.7.1(11). All other air conditioners shall meet the requirements in Table E 503.7.1(1). [ASHRAE 90.1:6.4.1.1]

E 503.4.1 Water-Cooled Centrifugal Chilling Packages. Equipment not designed for operation in accordance with AHRI 550/590 test conditions of 44.0°F (6.67°C) leaving and 54.0°F (12.22°C) entering chilled fluid temperatures and 2.4 gallons per minute per ton (gpm/ton) (0.00015 L/s/kg) evaporator fluid flow and with 85.0°F (29.44°C) entering and 94.3°F (34.61°C) leaving condenser-fluid temperatures, with 3.0 gpm/ton (0.00018 L/s/kg) condenser-fluid flow shall have maximum full-load kW/ton (FL) and part-load rating requirements adjusted in accordance with Equation E 503.4.1(1) through Equation E 503.4.1(3):

\[
FL_{adj} = FL/K_{adj} \quad \text{[Equation E 503.4.1(1)]}
\]

\[
PLV_{adj} = IPLV/IP/K_{adj} \quad \text{[Equation E 503.4.1(2)]}
\]

\[
K_{adj} = A \times B \quad \text{[Equation E 503.4.1(3)]}
\]

Where:

- \( FL \) = full-load kW/ton value from Table E 503.7.1(3)
- \( FL_{adj} \) = maximum full-load kW/ton rating, adjusted for nonstandard conditions
- \( IPLV/IP \) = IPLV/IP value from Table E 503.7.1(3)
- \( PLV_{adj} \) = maximum NPLV rating, adjusted for nonstandard conditions
- \( A \) = \( 0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.930273 \)
- \( B \) = 0.0015 \times LvgEvap + 0.934
- \( LIFT = LvgCond - LvgEvap \)
- \( LvgCond \) = Full-load condenser leaving fluid temperature (°F)
- \( LvgEvap \) = Full-load evaporator leaving temperature (°F)

The \( FL_{adj} \) and \( PLV_{adj} \) values shall only be applicable for centrifugal chillers in accordance with meeting all of the following full-load design ranges:

1. Minimum Evaporator Leaving Temperature: 36.0°F (2.22°C) < LvgEvap ≤ 60.0°F (15.56°C)
2. Maximum Condenser Leaving Temperature: 115.0°F (46.11°C) < LvgCond ≤ 115.0°F (46.11°C)
3. \( LIFT \) is not less than 20.0°F (-6.67°C) and not more than 80.0°F (26.67°C)

Manufacturers shall calculate the \( FL_{adj} \) and \( PLV_{adj} \) before determining whether to label the chiller in accordance with Section E 503.4.4. Chillers that are in accordance with ASHRAE 90.1 shall be labeled on chillers in accordance with the scope of ASHRAE 90.1.

Centrifugal chillers designed to operate outside of these ranges shall not be covered under this appendix.

Example: Path A, 600 ton (600 000 kg) centrifugal chiller Table E 503.7.1(3) efficiencies.

\[
F = 0.5600 \frac{\text{kW}}{\text{ton}}
\]

\[
IPLV = 0.5000 \frac{\text{kW}}{\text{ton}}
\]

\[
LvgCond = 91.16°F
\]

\[
LvgEvap = 42.00°F
\]

\[
LIFT = 91.16°F - 42.00°F = 49.16°F
\]

\[
K_{adj} = A \times B
\]
\[ A = 0.00000014592 \times (49.16)^4 - 0.0000346496 \times (49.16)^3 + 0.00314196 \times (49.16)^2 - 0.147199 \times (49.16) + 3.9302393073 = 4.0228 \]

\[ B = 0.0015 \times 42.00 + 0.934 = 0.9970 \]

\[ K_{adj} = A \times B \]

\[ FL_{adj} = 0.560/(1.0228 \times 0.9970) = 0.5490 \text{ kW/ton} \]

\[ PLV_{adj} = 0.500/(1.0228 \times 0.9970) = 0.4900 \text{ kW/ton} \] [ASHRAE 90.1:6.4.1.2.1]

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW, 1 gallon per minute = 0.06 L/s, °C = (°F-32)/1.8

E 503.4.1.1 Positive Displacement (air- and water-cooled) Chilling Packages. Equipment with an evaporator leaving fluid temperature more higher than 32.00°F (0.00°C) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature less than below 115.00°F (46.11°C) shall be in accordance show compliance with Table E 503.7.1(3) where when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure. [ASHRAE 90.1:6.4.1.2.2]

E 503.4.1.1 Packaged Terminal Air Conditioners. Nonstandard-size packaged terminal air conditioners and heat pumps with existing sleeves having an external wall opening of less than 16 inches (406 mm) high or less than 42 inches (1067 mm) wide and having a cross-sectional area less than 670 square inches (0.432 m²) shall be factory labeled in accordance with the as following follows:

“Manufactured for nonstandard-size applications only: Not to be installed in new construction projects.” [ASHRAE 90.1:6.4.1.5.2]

E 503.4.6 Zone Thermostatic Controls. The supply of heating and cooling energy to each zone shall be individually controlled by thermostatic controls responding to temperature within the zone. For the purposes of Section E 503.4.6, a dwelling unit shall be permitted to be considered a single zone.

Exceptions: Independent perimeter systems that are designed to offset only building envelope loads shall be permitted to serve one or more zones also served by an interior system, provided that:

(1) the perimeter system includes not less than one thermostatic control zone for each building exposure having walls facing only one orientation for 50 contiguous feet (15 240 mm) or more and

(2) the perimeter system heating and cooling supply is controlled by thermostatic controls located within the zones served by the system.

Exterior walls and semiexterior walls are considered to have different orientations where the exposures they face differ by more than 45 degrees (0.79 rad). [ASHRAE 90.1:6.4.3.1.1]

E 503.4.6.3.5 Automatic Control of HVAC in Hotel/Motel Guest Rooms. Hotels and motels with more than 50 guest rooms shall be provided with automatic controls for the HVAC equipment serving each guest room capable of and configured according to the requirements in Section E 503.4.6.3.1. [ASHRAE 90.1:6.4.3.3.5]

E 503.4.6.3.5.1 Guest Room HVAC Set-Point Control. Within 30 minutes of all occupants leaving the guest room, HVAC set points shall be automatically raised by not less than 4°F (2°C) from the occupant set point in the cooling mode and automatically lowered by at least 4°F (2°C) from the occupant set point in the heating mode. When the guest room is unrented and unoccupied, HVAC set points shall be automatically reset to 80°F (27°C) or higher in the cooling mode and to 60°F (16°C) or lower in the heating mode. Unrented and unoccupied guest rooms shall be determined by either of the following:

(1) The guest room has been continuously unoccupied for up to 16 hours.

(2) A networked guest room control system indicates the guest room is unrented and the guest room is unoccupied for no more than 30 minutes.

Exceptions:

(1) A networked guest room control system shall be permitted to return the thermostat set points to their default occupied set points 60 minutes prior to the time the room is scheduled to be occupied.

(2) Cooling for humidity control shall be permitted during unoccupied periods.

E 503.4.6.5 Enclosed Parking Garage Ventilation. Enclosed parking garage ventilation systems shall automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50 percent or less of design capacity, provided acceptable contaminant levels are maintained.

Exceptions:

(1) Garages not more less than 30 000 square feet (2787.09 m²) with ventilation systems that do not utilize mechanical cooling or mechanical heating.

(2) Garages that have a garage area to ventilation system motor nameplate hp horsepower ratio that exceeds 1500 square feet per horsepower (ft²/hp) (186.8 m²/kW) and do not utilize mechanical cooling or mechanical heating.

(3) Where not permitted by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.4.5]
E 503.4.6.7 Humidification and Dehumidification. Humidity control shall prevent the use of fossil fuel or electricity to produce relative humidity (RH) more than above 30 percent in the warmest zone served by the humidification system and to reduce the RH relative humidity valve to less than below 60 percent in the coldest zone served by the dehumidification system. Where a zone is served by a system or systems with both humidification and dehumidification capability, means (such as limit switches, mechanical stops, or, for DDC systems, software programming) shall be provided capable of preventing and configured to prevent simultaneous operation of humidification and dehumidification equipment.

Exceptions:
1. Zones served by desiccant systems, used with direct evaporative cooling in series.
2. Systems serving zones where specific humidity levels are required, such as museums and hospitals, and approved by the Authority Having Jurisdiction or required by accreditation standards and humidity controls are capable of and configured to maintain a dead band of not less than at least 10 percent RH relative humidity where no active humidification or dehumidification takes place.
3. Systems serving zones where humidity levels are required to be maintained with precision of not more than ± 5 percent RH relative humidity to comply with applicable codes or accreditation standards or as approved by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.6]

E 503.4.7.1.2 Piping Insulation. Piping shall be thermally insulated in accordance with Table E 503.7.3(1) and Table E 503.7.3(2).

Exceptions:
1. Factory-installed piping within HVAC equipment tested and rated in accordance with Section E 503.4 through Section E 503.4.4.1.
2. Piping that conveys fluids having a design operating temperature range between 60°F (16°C) and 105°F (41°C), inclusive.
3. Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electricity (such as roof and condensate drains, domestic cold water supply, and natural gas piping).
4. Where heat gain or heat loss will not increase energy use (such as liquid refrigerant piping).
5. For In piping 1 inch (25.4 mm) or less, insulation shall be not be required for strainers, control valves, and balancing valves. [ASHRAE 90.1:6.4.4.1.3]

E 503.4.7.1.3 Sensible Heating Panel. Thermally ineffective panel surfaces of sensible heating panels, including U-bends and headers, shall be insulated with not less than a minimum of R-3.5. Adjacent building envelope insulation shall be applied to counts toward this insulation value requirement. [ASHRAE 90.1:6.4.4.1.4]

E 503.4.7.1.4 Radiant Floor Heating. The bottom surfaces of floor structures incorporating radiant heating shall be insulated not less than with a minimum of R-3.5. Adjacent building envelope insulation shall be applied to counts toward this insulated value requirement.

Exception: Heated slab-on-grade floors incorporating radiant heating shall be in accordance with ASHRAE 90.1. [ASHRAE 90.1:6.4.4.1.5]

E 503.5.1.3 Dampers. Return air, exhaust or relief, and outdoor air dampers shall comply with Section E 503.4.6.4.2. [ASHRAE 90.1:6.5.1.1.4]

E 503.5.1.4 Relief of Excess Outdoor Air. Systems shall provide a means to relieve excess outdoor air during air economizer operation to prevent overpressurizing the building. The relief air outlet shall be located so as to avoid recirculation into the building. [ASHRAE 90.1:6.5.1.1.5]

E 503.5.5 Simultaneous Heating and Cooling Limitation, Zone Controls. Zone thermostatic controls shall prevent the following:
1. Reheating.
2. Recooling.
3. Mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems.
4. Other simultaneous operation of heating and cooling systems to the same zone.

Exceptions:
1. Zones for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:
   a. Twenty percent of the zone design peak supply for systems with DDC and 30 percent for other systems.
   b. The outdoor airflow rate required to be in accordance with the ventilation requirements of Chapter 4 or ASHRAE 62.1 for the zone.
   c. Any higher rate that is capable of can be demonstrating demonstrated, to the satisfaction of the Authority Having Jurisdiction, to reduce overall system annual energy usage use by offsetting reheating or recoling energy losses through a reduction in outdoor air intake for the system.
   d. The airflow rate required to be in accordance with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.

2. Zones with DDC that comply with the following:
   a. The airflow rate in dead band between heating and cooling does not exceed the larger of the following:
      1. Twenty percent of the zone design peak supply rate.
(2) The outdoor airflow rate required to be in accordance with the ventilation requirements of Chapter 4 or ASHRAE 62.1 for the zone.

(3) A higher rate that is capable of can be demonstrating demonstrated to the satisfaction of the Authority Having Jurisdiction, to reduce overall system annual energy usage by offsetting reheat or frecool energy losses through a reduction in outdoor air intake.

(4) The airflow rate required in accordance with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.

(b) The airflow rate that is reheated, recooled, or mixed shall be less than 50 percent of the zone design peak supply rate.

(c) The first stage of heating consists of modulating the supply air temperature set point up to a maximum setpoint while the airflow is maintained at the dead band flow rate.

(d) The second stage of heating consists of modulating the airflow rate from the dead band flow rate up to the heating maximum flow rate.

(3) Laboratory exhaust systems in accordance that comply with Section E 503.5.11.3.

(4) Zones where not less than at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered energy (including condenser heat) or site-solar energy source. [ASHRAE 90.1:6.5.2.1]

E 503.5.5.2.3 Hydronic (Water Loop) Heat Pump Systems. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower) and heat addition (e.g., boiler) shall have the following:

(1) Controls that are capable of and configured to provide a heat pump water supply temperature dead band of not less than at least 20°F (11°C) between initiation of heat rejection and heat addition by the central devices (e.g., tower and boiler).

(2) For climate zone 3 through zone 8, where a closed-circuit cooling tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection) or low-leakage positive closure dampers shall be provided. Where an open-circuit cooling tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. Where an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, dead bands of less than 20°F (11°C) shall be permitted. [ASHRAE 90.1:6.5.2.2.3]

E 503.5.6.1.1 Motor Nameplate Horsepower. For each fan, the selected fan motor shall be not larger than the first available motor size more greater than the brake horsepower (bhp) (kW). The fan brake horsepower bhp shall be indicated on the design documents to allow for compliance verification by the Authority Having Jurisdiction.

Exceptions:

(1) For fans less than 6 bhp (4.5 kW), where the first available motor larger than the bhp (kW) has a nameplate rating within 30 percent of the bhp (kW), the next larger nameplate motor size shall be permitted to be selected.

(2) For fans 6 bhp (4.5 kW) and larger, where the first available motor larger than the bhp (kW) has a nameplate rating within 30 percent of the bhp (kW), the next larger nameplate motor size shall be permitted to be selected.

(3) Systems that are in accordance with Section E 503.5.6.1, Option 1.

(4) Fans with motor nameplate horsepower of less than 1 hp (0.7 kW). [ASHRAE 90.1:6.5.3.1.2]

E 503.5.6.2 Supply Fan Airflow Control. Each cooling systems listed in Table E 503.5.6.2 shall be designed to vary the indoor supply fan airflow as a function of load and shall be in accordance comply with the following requirements:

(1) DX and chilled-water cooling units that control the capacity of the mechanical cooling directly based on space temperature shall have a minimum of two stages of fan control. Low or minimum speed shall not exceed 66 percent of full speed. At low or minimum speed, the fan system shall draw not no more than 40 percent of the fan power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.

(2) Other All other units, including DX cooling units and chilled-water units that control the space temperature by modulating the airflow to the space, shall have modulating fan control. Minimum speed shall not exceed 50 percent of full speed. At minimum speed, the fan system shall draw not no more than 30 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.

(3) Units that include an air-side economizer to comply meet with the requirements of Section E 503.5 through Section E 503.5.4.1 shall have not less than a minimum of two speeds of fan control during economizer operation.

Exceptions:

(1) Modulating fan control shall not be required for chilled-water and evaporative cooling units with less than 1 hp (0.7 kW) fan motors where the units are not used to provide ventilation air and where the indoor fan cycles with the load.

(2) Where the volume of outdoor air required to comply meet with the ventilation requirements of Chapter 4 or ASHRAE 62.1 at low speed exceeds the air that would be delivered at the speed defined in Section E 503.5.6.2(1), or Section E 503.5.6.2(2), then the minimum speed shall be selected to provide the required ventilation air. [ASHRAE 90.1:6.5.3.2.1]
E 503.5.6.3 Multiple-Zone VAV System Ventilation Optimization Control. Multiple-zone VAV systems with DDC of individual zone boxes reporting to a central control panel shall include a means to automatically reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency in accordance with ASHRAE 62.1. [ASHRAE 90.1:6.5.4.4]

Exceptions:
(1) VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units.
(2) Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements. [ASHRAE 90.1:6.5.3.3]

E 503.5.6.4 Supply Air Temperature Reset Controls. Multiple zone HVAC systems shall include controls that automatically reset the supply air temperature in response to representative building loads, or to outdoor air temperature. The controls shall reset the supply air temperature to not less than at least 25 percent of the difference between the design supply air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity shall be permitted. Zones that are expected to experience relatively constant loads, such as electronic equipment rooms, shall be designed for the fully reset supply temperature.

Exceptions:
(1) Climate zones 0A, 1A, 2A, and 3A.
(2) Systems that prevent reheating, recooling, or mixing of heated and cooled supply air.
(3) Systems where not less than 75 percent of the energy for reheating, (on an annual basis,) is from site recovered energy or site solar energy sources. [ASHRAE 90.1:6.5.3.5]

E 503.5.7.3 Chilled- and Hot-Water Temperature Reset Controls. Chilled- and hot-water systems with a design capacity exceeding 300 000 Btu/h (88 kW) supplying chilled or heated water (or both) to comfort conditioning systems shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature. Where DDC is used to control valves, the set point shall be reset based on valve positions until one valve is nearly wide open or set point limits of the system equipment or application have been reached.

Exceptions:
(1) Where chilled-water supply is already cold, such as chilled water supplied from a district cooling or thermal energy storage system, such that blending would be required to achieve the reset chilled-water supply temperature.
(2) Where a specific temperature is required for a process.
(3) Water temperature reset is not required where valve position is used to comply with Section E 503.5.7. [ASHRAE 90.1:6.5.4.4]

E 503.5.7.5 Pipe Sizing. Chilled-water and condenser-water piping shall be designed such that the design flow rate in a pipe each piping segment does shall not exceed the values listed in Table E 503.5.7.5 for the appropriate total annual hours of operation. Pipe Piping size selections for systems that operate under variable flow conditions, such as (e.g., modulating two-way control valves at coils), and that contain variable-speed pump motors shall be permitted to be made from the “Variable Flow/Variable Speed” columns. All others shall be made from the “Other” columns.

Exceptions:
(1) Design flow rates exceeding the values in Table E 503.5.7.5 shall be permitted in specific sections of pipe where the pipe piping if the piping in question is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during more than 30 percent or more of operating hours.
(2) Piping systems that have not more than the equivalent or lower total pressure drop than the same system constructed with standard weight steel pipe with piping and fittings sized in accordance with Table E 503.5.7.5. [ASHRAE 90.1:6.5.4.6]

E 503.5.8 Heat Rejection Equipment. Section E 503.5.8 through Section E 503.5.9 apply to heat-rejection equipment used in comfort cooling systems, such as air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers.

Exception: Heat-rejection devices whose energy usage is included in the equipment efficiency ratings listed in Table E 503.7.1(1) through Table E 503.7.1(4). [ASHRAE 90.1:6.5.5.1]

E 503.5.8.1 Fan Speed Control. The fan system on a heat-rejection device powered by an individual motor or an array of motors with a connected power, including the motor service factor, totaling 5 hp (3.7 kW) or more shall have controls and/or devices (such as variable-speed control) that shall result in fan motor demand of no more than 30 percent of design wattage at 50 percent of the design airflow and that shall automatically change modulate the fan speed to control the leaving fluid temperature or condensing temperature or pressure of the heat-rejection device.

Exceptions:
(1) Condenser fans serving multiple refrigerant circuits or fluid cooling circuits.
(2) Condenser fans serving flooded condensers. [ASHRAE 90.1:6.5.5.2.1]

E 503.5.10.1.2 Capacity. The required heat recovery system shall have the capacity to provide the smaller of:
(1) Sixty percent of the peak heat-rejection load at design conditions or...
Preheat of the peak service hot-water draw to 85°F (29°C).

Exceptions:
1. Facilities that employ condenser heat recovery for space heating with a heat recovery design exceeding 30 percent of the peak water-cooled condenser load at design conditions.
2. Facilities that provide 60 percent of their service water heating from site-solar energy, or site-recovered energy, or from other sources. [ASHRAE 90.1:6.5.6.2.2]

E 503.5.11.1 503.5.11.1 Conditioned Supply Air Transfer Air. Conditioned supply air delivered to a space with a kitchen hood mechanical exhaust shall not exceed the greater of the following:
1. The supply flow required to be in accordance with the space heating or cooling load;
2. The ventilation rate required by the Authority Having Jurisdiction, the Facility Environmental Health and Safety department, or ASHRAE 62.1; or
3. The hood mechanical exhaust flow minus the available transfer air from adjacent conditioned spaces, or return air plenums on the same floor, not in different smoke or fire compartments, and that at their closest point are within 15 feet (4572 mm) of each other. Available transfer air is that portion of outdoor ventilation air that:
   a. is not required to satisfy other exhaust needs, such as restrooms, and
   b. is not required to maintain pressurization of adjacent other spaces.
   c. is transferable according to applicable codes and standards and to the class of air recirculation limitations in ASHRAE 62.1.

Exceptions:
1. Biosafety level classified laboratories 3 or higher.
2. Vivarium spaces.
3. Spaces that are required by applicable codes and standards to be maintained at positive pressure relative to adjacent spaces. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.
4. Spaces where the demand for transfer air may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy. [ASHRAE 90.1:6.5.7.1.2 6.5.7.1]

E 503.5.11.2 503.11.2 Kitchen Exhaust Systems. (remaining text unchanged)
E 503.5.11.2 503.11.2.1 Exhaust Flow Rate. (remaining text unchanged)
E 503.5.11.2.1 Kitchen or Dining Facility. (remaining text unchanged)
E 503.5.11.2.2 503.11.2.3 Performance Testing. An approved field test method shall be used to evaluate design airflow rates and demonstrate proper capture and containment performance of installed commercial kitchen exhaust systems. Where demand ventilation systems are utilized to be in accordance with Section E 503.5.11.2.1, additional performance testing shall be provided required to demonstrate proper capture and containment at minimum airflow. [ASHRAE 90.1:6.5.7.2.4]

E 503.5.12.1 Heating Enclosed Spaces. Radiant heating systems that are used as primary or supplemental heating for enclosed spaces shall be in conformance with the governing provisions of the standard, space heating shall be in accordance with this appendix, including, but not limited to, the following:
1. Radiant hydronic ceiling or floor panels (used for heating or cooling).
2. Combination or hybrid systems incorporating radiant heating (or cooling) panels.
3. Radiant heating (or cooling) panels used in conjunction with other systems such as VAV or thermal storage systems.
   [ASHRAE 90.1:6.5.8.2]

E 503.5.13 Hot Gas Bypass Limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table E 503.5.13 for VAV units and single-zone VAV units. Hot-gas bypass shall not be used on constant-volume units. [ASHRAE 90.1:6.5.9]

E 503.6.3.1 Required Information. Construction documents shall require that an operating manual and maintenance manual be provided to the building owner. The manuals shall include, at a minimum, the following:
1. Submittal data stating equipment rating and selected options for each piece of equipment requiring maintenance.
2. Operation manuals and maintenance manuals for each piece of equipment requiring maintenance. Required routine maintenance actions shall be clearly identified.
3. Names and addresses of not less than one qualified service agency.
4. A complete narrative of how each system is intended to operate.
   The Authority Having Jurisdiction shall only check to ensure that the construction documents required are provided and shall not expect copies of any of the materials. [ASHRAE 90.1:8.7.2]
### TABLE E 503.8.1
**POWER USAGE EFFECTIVENESS (PUE) MAXIMUM**

[ASHRAE 90.1: TABLE 6.6.1

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>PUE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A</td>
<td>1.64</td>
</tr>
<tr>
<td>0B</td>
<td>1.62</td>
</tr>
<tr>
<td>1A</td>
<td>1.61</td>
</tr>
<tr>
<td>1B</td>
<td>1.53</td>
</tr>
<tr>
<td>2A</td>
<td>1.49</td>
</tr>
<tr>
<td>2B</td>
<td>1.45</td>
</tr>
<tr>
<td>3A</td>
<td>1.41</td>
</tr>
<tr>
<td>3B</td>
<td>1.42</td>
</tr>
<tr>
<td>3C</td>
<td>1.39</td>
</tr>
<tr>
<td>4A</td>
<td>1.36</td>
</tr>
<tr>
<td>4B</td>
<td>1.38</td>
</tr>
<tr>
<td>4C</td>
<td>1.38</td>
</tr>
<tr>
<td>5A</td>
<td>1.36</td>
</tr>
<tr>
<td>5B</td>
<td>1.33</td>
</tr>
<tr>
<td>5C</td>
<td>1.36</td>
</tr>
<tr>
<td>6A</td>
<td>1.34</td>
</tr>
<tr>
<td>6B</td>
<td>1.33</td>
</tr>
<tr>
<td>4B</td>
<td>1.53</td>
</tr>
<tr>
<td>2B</td>
<td>1.45</td>
</tr>
<tr>
<td>3B</td>
<td>1.42</td>
</tr>
<tr>
<td>4B</td>
<td>1.38</td>
</tr>
<tr>
<td>5B</td>
<td>1.33</td>
</tr>
<tr>
<td>6B</td>
<td>1.33</td>
</tr>
<tr>
<td>3C</td>
<td>1.39</td>
</tr>
<tr>
<td>4C</td>
<td>1.38</td>
</tr>
<tr>
<td>5C</td>
<td>1.36</td>
</tr>
<tr>
<td>7</td>
<td>1.32</td>
</tr>
<tr>
<td>8</td>
<td>1.30</td>
</tr>
</tbody>
</table>

* PUE₀ and PUE₁ shall not include energy for battery charging.

#### E 503.8.2 Computer Room (PUE₀)

The computer room PUE₀ shall be not more is less than or equal to the values listed in Table E 503.8.1. The PUE₀ shall be the highest value determined at outdoor cooling design temperatures, and shall be limited to systems utilizing only using electricity for an energy source. The PUE₀ shall be calculated for the following two conditions:

1. One hundred percent design IT equipment energy, and
2. Fifty percent design IT equipment energy. [ASHRAE 90.1:6.6.1.2]
### Table E 503.7.1(6)
GAS- AND OIL-FIRED BOILERS - MINIMUM EFFICIENCY REQUIREMENTS

[ASHRAE 90.1: TABLE 6.8.1-6]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>MINIMUM EFFICIENCY</th>
<th>EFFICIENCY AS OF 3/2/2020</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers, steam</td>
<td>Gas fired — all, except natural draft</td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h</td>
<td>79% Et</td>
<td>79% Et</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td>Gas fired</td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h</td>
<td>79% Et</td>
<td></td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>&gt;2 500 000 Btu/h</td>
<td>79% Et</td>
<td></td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil fired</td>
<td>&lt;300 000 Btu/h</td>
<td>82% AFUE</td>
<td></td>
<td>82% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h</td>
<td>81% Et</td>
<td></td>
<td>81% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>&gt;2 500 000 Btu/h</td>
<td>81% Et</td>
<td></td>
<td>81% Et</td>
<td>10 CFR Part 431</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

### Table E 503.7.1(10)
ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS - MINIMUM EFFICIENCY REQUIREMENTS

[ASHRAE 90.1: TABLE 6.8.1-10]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Air cooled (heating mode)</td>
<td>&lt;65 000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>VRF Multi-split system</td>
<td>7.7 HSPF</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h (cooling capacity)</td>
<td>—</td>
<td>VRF Multi-split system 47°F db/43°F wb outdoor air</td>
<td>3.3 (\text{COP}_H)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 17°F db/15°F wb outdoor air</td>
<td>2.25 (\text{COP}_H)</td>
<td></td>
</tr>
</tbody>
</table>

256
TABLE E 503.7.3(1)
MINIMUM PIPE INSULATION THICKNESS FOR HEATING AND HOT WATER SYSTEMS¹, ², ³, ⁴, ⁵
(STEAM, STEAM CONDENSATE, HOT WATER HEATING, AND DOMESTIC WATER SYSTEMS)
[ASHRAE 90.1: TABLE 6.8.3-1]

<table>
<thead>
<tr>
<th>FLUID OPERATING TEMPERATURE RANGE (°F) AND USAGE</th>
<th>INSULATION CONDUCTIVITY</th>
<th>≥NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONDUCTIVITY Btu•inch/(h•ft²•°F)</td>
<td>MEAN RATING TEMPERATURE °F</td>
</tr>
<tr>
<td>&gt;350</td>
<td>0.32 - to 0.34</td>
<td>250</td>
</tr>
<tr>
<td>251 - to 350</td>
<td>0.29 - to 0.32</td>
<td>200</td>
</tr>
<tr>
<td>201 - to 250</td>
<td>0.27 - to 0.30</td>
<td>150</td>
</tr>
<tr>
<td>141 - to 200</td>
<td>0.25 - to 0.29</td>
<td>125</td>
</tr>
<tr>
<td>105 - to 140</td>
<td>0.22 - to 0.28</td>
<td>100</td>
</tr>
</tbody>
</table>

For SI units: °C=(°F-32)/1.8, 1 inch = 25 mm, 1 British thermal unit inch per hour square foot degree Fahrenheit = [0.1 W/(m•K)]

Notes:
¹ For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

\[ T = r(1 + t/r)^{K/k} - 1 \]

Where:
- \( T \) = minimum insulation thickness (inches).
- \( r \) = actual outside radius of pipe (inches).
- \( t \) = insulation thickness listed in this table for applicable fluid temperature and pipe size.
- \( K \) = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu•in/(h•ft²•°F)] [W/(m•K)].
- \( k \) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

² These thicknesses shall be based on energy efficiency considerations only. Additional insulation shall be permitted to is sometimes required relative to safety issues/surface temperature.

³ Piping For piping smaller than 1 1/2 inches (40 mm) or less and located in partitions within conditioned spaces, reduction of insulation thickness these thicknesses by 1 inch (25.4 mm) shall be permitted (before thickness adjustment required in footnote 1), but not a thickness less than to thicknesses below 1 inch (25.4 mm).

⁴ For direct-buried heating and hot water system piping, reduction of insulation thickness these thicknesses by 1 1/2 inch (40 mm) shall be permitted (before thickness adjustment required in footnote 1), but not a thickness less than to thicknesses below 1 inch (25.4 mm).

⁵ Table E 503.7.3(1) is based on steel pipe. Non-metallic pipes, less than schedule 80 thickness or less shall use the table values. For other non-metallic pipes having a thermal resistance more than that of steel pipe, reduced insulation thicknesses shall be are permitted where documentation is provided showing that the pipe with the proposed insulation has less no more heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.3(1).
### TABLE E 503.7.3(2)
**MINIMUM PIPE INSULATION THICKNESS FOR COOLING SYSTEMS**
(CHILLED WATER, BRINE, AND REFRIGERANT)\(^1,2,3,4\)
[ASHRAE 90.1: TABLE 6.8.3-2]

<table>
<thead>
<tr>
<th>FLUID OPERATING TEMPERATURE RANGE (°F) AND USAGE</th>
<th>CONDUCTIVITY Btu•inch/(h•f²•°F)</th>
<th>MEAN RATING TEMPERATURE°F</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
<th>INSULATION THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>40°F - to 60°F</td>
<td>0.21 - to 0.27</td>
<td>75</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>&lt;40°F</td>
<td>0.20 - to 0.26</td>
<td>50</td>
<td>0.5</td>
<td>1.0</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8, 1 inch = 25 mm, 1 British thermal unit inch per hour square foot degree Fahrenheit = [0.1 W/(m•K)]

**Notes:**

1. For insulation outside the stated conductivity range, the minimum thickness \(T\) shall be determined as follows:
   \[
   T = r \left(\frac{1}{K} + \frac{t}{k} K/k - 1\right)
   \]
   Where:
   - \(T\) = minimum insulation thickness (inches).
   - \(r\) = actual outside radius of pipe (inches).
   - \(t\) = insulation thickness listed in this table for applicable fluid temperature and pipe size.
   - \(K\) = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu•inch/(h•f²•°F)] [W/(m•K)].
   - \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

2. These thicknesses are based on energy efficiency considerations only. Issues such as water, vapor permeability, or surface condensation require vapor retarders or additional insulation.

3. Insulation shall not be required for direct-buried cooling system piping. Insulation is not required.

4. Table E 503.7.3(2) is based on steel pipe. Non-metallic pipes less than schedule 80 thickness or less shall use the table values. For other non-metallic pipes having thermal resistance more than that of steel pipe, reduced insulation thicknesses are permitted where documentation is provided showing that the pipe with the proposed insulation has less no more heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.3(2).

Note: ASHRAE 127 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

**SUBSTANTIATION:**
In accordance with IAPMO Governing Consensus Project, Appendix E has been revised to correlate with the latest ASHRAE 90.1-2016.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** **AFFIRMATIVE:** 25  **NOT RETURNED:** 1  HOWARD
Item #: 153

UMC 2021  Section: E 403.1, Table 1701.2

SUBMITTER: Billy Smith
ASPE

RECOMMENDATION:
Revise text

E 403.0 HVAC Water Use.
E 403.1 Operation and Maintenance. Cooling towers shall be operated and maintained in accordance with ASHRAE 188.

(renumber remaining sections)

TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE 188-2015</td>
<td>Legionellosis: Risk Management for Building Water Systems</td>
<td>Miscellaneous</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
Cooling towers have been identified as an opportunistic environment for Legionella bacteria growth and release to the environment where people risk exposure to the organisms and the resulting health effects. ASHRAE standard 188 provides specific Legionella risk mitigation elements for cooling towers and the related mechanical components. The standard provides for an initial evaluation of the system and ongoing measures to reduce human exposure/risk to the bacteria.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed language is a maintenance requirement and is not within the scope of the UMC.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 24  ABSTAIN: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF AFFIRMATIVE:
MANN: ASHRAE 188 is not an appropriate standard for the UMC. This would add undue costs to small facilities. This should be incorporated into a facilities maintenance procedures.

EXPLANATION OF ABSTAIN:
EGG: Cooling towers are a risk to health and human safety because they can spread Legionella. I believe this should be addressed in the UMC in the appropriate place (yet to be identified).
E 503.0 Heating, Ventilation, and Air-Conditioning – Other than Low-Rise Residential Buildings.

E 503.1.3 Alterations to Heating, Ventilating, Air-Conditioning, and Refrigeration in Existing Buildings. New HVACR equipment as a direct replacement of existing HVACR equipment shall be in accordance with the minimum requirements following sections as applicable to the equipment being replaced:

1. Section E 503.3
2. Section E 503.4
3. Section E 503.4.6
4. Section E 503.4.6.2
5. Section E 503.4.6.3
6. Section E 503.4.6.4
7. Section E 503.4.6.8
8. Section E 503.4.6.9
9. Section E 503.4.6.11
10. Section E 503.5.1
11. Section E 503.5.3
12. Section E 503.5.3.1
13. Section E 503.5.6.1.2
14. Section E 503.5.6.2
15. Section E 503.5.6.5
16. Section E 503.5.7
17. Section E 503.5.7.2
18. Section E 503.5.8.1. [ASHRAE 90.1:6.1.1.3.1]

E 503.4.6 Zone Thermostatic Controls. The supply of heating and cooling energy to each zone shall be individually controlled by thermostatic controls responding to temperature within the zone. For the purposes of Section E 503.4.6, a dwelling unit shall be permitted to be considered a single zone.

Exceptions: Independent perimeter systems that are designed to offset only building envelope loads shall be permitted to serve one or more zones also served by an interior system provided:

1. The perimeter system includes not less than one thermostatic control zone for each building exposure having exterior walls facing only one orientation for 50 contiguous feet (15 240 mm) or more, and
2. The perimeter system heating and cooling supply is controlled by a thermostatic control(s) located within the zone(s) served by the system.

Exterior walls and semieexterior walls are considered to have different orientations where the directions exposures they face differ by more than 45 degrees (0.79 rad). [ASHRAE 90.1:6.4.3.1.1]

E 503.4.6.1 Dead Band. Where used to control both heating and cooling, zone thermostatic controls shall be capable of providing and configured to provide a temperature range or dead band of not less than 5°F (3°C) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

Exceptions:
(1) Thermostats that require manual changeover between heating and cooling modes.
(2) Special occupancy or special applications where wide temperature ranges are not acceptable (such as retirement homes, process applications, museums, some areas of hospitals) and are approved by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.1.2]

E 503.4.6.2 Setpoint Overlap Restriction. Where the heating and cooling to a zone are controlled by separate zone thermostatic controls located within the zone, means (such as limit switches, mechanical stops, or, for DDC systems, software programming) shall be provided to prevent the heating setpoint from exceeding the cooling setpoint minus any applicable proportional band. [ASHRAE 90.1:6.4.3.2]

E 503.4.6.3.2 Setback Controls. Heating systems shall be equipped with controls capable of and configured to automatically restart and temporarily operate the system as required to maintain zone temperatures above an adjustable heating setpoint of not less than 10°F (6°C) below the occupied heating setpoint. Cooling systems shall be equipped with controls capable of and configured to automatically restart and temporarily operate the mechanical cooling system as required to maintain zone temperatures below an adjustable cooling setpoint of not less than 5°F (3°C) above the occupied cooling setpoint or to prevent high space humidity levels.

Exception: Radiant heating systems capable of and configured with a setback heating setpoint at not less than 4°F (2°C) below the occupied heating setpoint. [ASHRAE 90.1:6.4.3.3.2]

E 503.4.6.3.4 Zone Isolation. HVAC systems serving zones that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones shall be permitted to be grouped into a single isolation area provided it does not exceed 25 000 square feet (2322.6 m²) of conditioned floor area and does not include more than one floor. Each isolation area shall be equipped with isolation devices capable of and configured to automatically shutting shutoff the supply of conditioned air and outdoor air to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of Section E 503.4.6.3.1. For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions: Isolation devices and controls are not required for the following:
(1) Exhaust air and outdoor air connections to isolation zones where the fan system to which they connect is not more than 5000 ft³/min (2.3597 m³/s).
(2) Exhaust airflow from a single isolation zone of less than 10 percent of the design airflow of the exhaust system to which it connects.
(3) Zones intended to operate continuously or intended to be inoperative only when all other zones are inoperative. [ASHRAE 90.1:6.4.3.3.4]

E 503.4.6.4 Ventilation System Controls. Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of and configured to being automatically closed during normal building operation and are interlocked to open in accordance with as required by fire and smoke detection systems. [ASHRAE 90.1:6.4.3.4.1]

E 503.4.6.4.1 Shutoff Damper Controls. Outdoor air intake and exhaust systems shall be equipped with motorized dampers that will automatically shut where when the systems or spaces served are not in use. Ventilation outdoor air and exhaust or relief dampers shall be capable of and configured to automatically shutting shutoff during preoccupancy building warm-up, cooldown, and setback, except where when ventilation reduces energy costs or where when ventilation shall be supplied to be in accordance with the requirements of this code comply with the code requirements.

Exceptions:
(1) Backdraft gravity (nonmotorized) dampers shall be permitted for exhaust and relief in buildings less than three stories in height, and for ventilation air intakes and exhaust and relief dampers in buildings of any height located in climate zones 1 through zone 0, 1, 2 and 3. Back-draft dampers for ventilation air intakes shall be protected from direct exposure to wind.
(2) Backdraft gravity (nonmotorized) dampers shall be permitted in systems with a design outdoor air intake or exhaust capacity of 300 ft³/min (0.142 m³/s) or less.
(3) Dampers shall not be required in ventilation or exhaust systems serving unconditioned spaces.
(4) Dampers shall not be required in exhaust systems serving Type 1 kitchen exhaust hoods. [ASHRAE 90.1:6.4.3.4.2]
TABLE E 503.4.6.4.2
MAXIMUM DAMPER LEAKAGE
(cubic foot per minute per square foot) at 1.0 in. w.g
[ASHRAE 90.1: TABLE 6.4.3.4.3]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>VENTILATION AIR INTAKE</th>
<th>EXHAUST/RELIEF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NONMOTORIZED*</td>
<td>MOTORIZED</td>
</tr>
<tr>
<td>0, 1, 2 any height</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

(portion of table not shown remain unchanged)

E 503.4.6.4.3 Ventilation Fan Controls. Fans with motors more than 0.75 hp (0.56 kW) shall have automatic controls in accordance with Section E 503.4.6.3.1 that are capable of and configured to shutting off fans where when not required.

Exception: HVAC systems intended to operate continuously. [ASHRAE 90.1:6.4.3.4.4]

E 503.4.6.8 Freeze Protection and Snow or Ice Melting Systems. Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls capable of and configured to shutting off the systems where when outdoor air temperatures are more than 40°F (4°C) or where when the conditions of the protected fluid will prevent freezing. Snow- and ice-melting systems shall include automatic controls capable of and configured to shutting off the systems where when the pavement temperature is more than 50°F (10°C) and no precipitation is falling, and an automatic or manual control that will allow shutoff where when the outdoor temperature is more than 40°F (4°C) so that the potential for snow or ice accumulation is negligible. [ASHRAE 90.1:6.4.3.7]

E 503.4.6.9 Ventilation Controls for High-Occupancy Areas. Demand control ventilation (DCV) shall be required for spaces that are more than 500 square feet (46.45 m²) and with a design occupancy for ventilation of not less than 25 people per 1000 square feet (92.9 m²) of floor area and served by systems with one or more of the following:

1. An Air-side economizer.
2. An Automatic modulating control of the outdoor air damper.
3. A Design outdoor airflow more than 3000 ft³/min (1.4158 m³/s).

Exceptions:
1. Systems with exhaust air energy recovery in accordance with Section E 503.5.10.
2. Multiple-zone systems without DDC of individual zones communicating with a central control panel.
3. Systems with a design outdoor airflow less than 750 ft³/min (0.3540 m³/s).
4. Spaces where more than 75 percent of the space design outdoor airflow is required for makeup air that is exhausted from the space or transfer that is required for makeup air that is exhausted from other spaces.
5. Spaces with one of the following occupancy categories in accordance with Chapter 4 or ASHRAE 62.1: correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating. [ASHRAE 90.1:6.4.3.8]

E 503.5 Prescriptive Path, Economizers. Cooling systems that have fans shall include either an air or water economizer or fluid economizer in accordance with Section E 503.5.1 through Section E 503.5.4.1.

Exceptions: Economizers shall not be required for the following systems:
1. Individual fan-cooling units with a supply capacity less than the minimum listed in Table E 503.5(1) for comfort cooling applications and Table E 503.5(2) for computer room applications.
2. Chilled-water cooling systems without a fan or that use induced airflow, where the total capacity of these systems is less than 1 000 000 Btu/h (293 kW) in Climate Zones 0, 1B, and 2 through 4; less than 1 400 000 Btu/h (410 kW) in Climate Zones 5 through 8; or any size in Climate Zone 1A.
3. Systems that include nonparticulate air treatment in accordance with ASHRAE 62.1.
4. In hospitals and ambulatory surgery centers, where more than 75 percent of the air designed to be supplied by the system is to spaces that are required to be humidified more than 35°F (2°C) dew-point temperature in accordance to comply with applicable codes or accreditation standards.
5. In all other buildings, where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified more than 35°F (2°C) dew-point temperature to satisfy process needs. This exception shall not apply to computer rooms.
6. Systems that include a condenser heat recovery system with a minimum capacity in accordance with Section E 503.5.10.1.2.
Systems that serve residential spaces where the system capacity is less than five times the requirement listed in Table E 503.5(1).

Systems that serve spaces whose sensible cooling load at design conditions, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60°F (16°C).

Systems expected to operate less than 20 hours per week.

Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

For comfort cooling where the cooling efficiency is not less than the efficiency improvement requirements in accordance with Table E 503.5(3).

Dedicated systems for computer rooms where a minimum of 75 percent of the design load serves one of the following:

(a) The total design cooling load of all computer rooms in the building is less than 3 000 000 Btu/h (879 kW) and the building in which they are located is not served by a centralized chilled water plant.

(b) The room total design cooling load is less than 600 000 Btu/h (176 kW) and the building in which they are located is served by a centralized chilled water plant.

(c) The local water authority does not permit cooling towers.

(d) Less than 600 000 Btu/h (176 kW) of computer room cooling equipment capacity is being added to an existing building.

Dedicated systems for computer rooms where a minimum of 75 percent of the design load serves one of the following:

(a) Spaces classified as an essential facility.

(b) Spaces having a mechanical cooling design of Tier IV in accordance with TIA 942.

(c) Spaces classified as Critical Operations Power Systems (COPS) in accordance with NFPA 70.

(d) Spaces where core clearing and settlement services are performed such that their failure to settle pending financial transactions is capable of systemic risk in accordance with “The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System” (April 7, 2003). [ASHRAE 90.1:6.5.1]

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY WHERE AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0a, 0b, 1a, 1b</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2a, 2b, 3a, 4a, 5a, 6a, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8</td>
<td>≥54 000 Btu/h</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY WHERE AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a, 1b, 2a, 2b, 3a, 3b</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2b, 3a, 4a, 5a, 6a, 7, 8</td>
<td>≥135 000 Btu/h</td>
</tr>
<tr>
<td>3b, 3c, 4b, 4c, 5b, 5c, 6b</td>
<td>≥65 000 Btu/h</td>
</tr>
</tbody>
</table>

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

* Where a unit is rated with an IPLV, IEER or SEER, to eliminate the required air or water economizer, the minimum cooling efficiency of the HVAC unit shall be increased by the percentage shown. Where the HVAC unit is rated with a full load metric like EER or COP cooling, these shall be increased by the percentage shown.

(portions of table not shown remain unchanged)
E 503.5.1 Air Economizers, Design Capacity. Air economizer systems shall be capable of and configured to modulating outdoor air and return air dampers to provide up to 100 percent of the design supply air quantity as outdoor air for cooling. [ASHRAE 90.1:6.5.1.1.1]

E 503.5.1.1 Control Signal. Economizer dampers controls shall be capable of and configured to be sequenced the dampers with the mechanical cooling equipment and shall not be controlled by only mixed air temperature.

Exception: The use of mixed air temperature limit control shall be permitted for systems controlled from space temperature (such as single-zone systems). [ASHRAE 90.1:6.5.1.1.2]

E 503.5.1.2 High-Limit Shutoff. Air economizers shall be capable of and configured to automatically reduce outdoor air intake to the design minimum outdoor air quantity where outdoor air intake will no longer reduce cooling energy use. High-limit shutoff control types and associated setpoints for specific climate zones shall be chosen from Table E 503.5.1.2. [ASHRAE 90.1:6.5.1.1.3]

E 503.5.2 Water Fluid Economizers, Design Capacity. Water fluid economizer systems shall be capable of providing up to 100 percent of the expected system cooling load at outdoor air temperatures of not more than 50°F (10°C) dry bulb or 45°F (7°C) wet bulb.

Exceptions:
(1) Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at the dry bulb and wet bulb temperatures in accordance with Table E 503.5.2 is achieved met with evaporative water-cooled fluid economizers.
(2) Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at the dry bulb temperatures in accordance with listed in Table E 503.5.2 is achieved met with dry cooler water air-cooled fluid economizers.
(3) Systems where dehumidification requirements are not capable of being met using outdoor air temperatures of 50°F (10°C) dry bulb or 45°F (7°C) wet bulb, and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb or 40°F (4°C) wet bulb is achieved met with evaporative water-cooled fluid economizers. [ASHRAE 90.1:6.5.1.2.1]

E 503.5.2.1 Maximum Hydronic Pressure Drop. Precooling coils and water fluid-to-water heat exchangers used as part of a water fluid economizer system shall either have a water-side pressure drop of less than 15 feet of water (45 kPa), or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps where the system is in the normal cooling (non-economizer) mode. [ASHRAE 90.1:6.5.1.2.2]

E 503.5.3 Integrated Economizer Control. Economizer systems shall be integrated with the mechanical cooling system and be capable of and configured to provide partial cooling even where additional mechanical cooling is required to be in accordance with the remainder of the cooling load. Controls shall not false load the mechanical cooling systems by limiting or disabling the economizer or by other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Units that include an air economizer shall comply with the following:
(1) Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls such that the outdoor air damper is at the 100 percent open position when mechanical cooling is on, and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).
(2) DX units that control the capacity of the mechanical cooling directly based on occupied space temperature shall have a minimum of two stages of mechanical cooling capacity per the following effective dates:
   (a) Not less than 75 000 Btu/h (22kW) Rated Capacity—Effective 1/1/2014
   (b) Not less than 65 000 Btu/h (18kW) Rated Capacity—Effective 1/1/2016 [ASHRAE 90.1:6.5.1.3]
(2) DX units with a rated capacity no less than 65 000 Btu/h (18 kW) that control the capacity of the mechanical cooling directly based on occupied space temperature shall have not less than two stages of mechanical cooling capacity.
(3) E 503.5.3.1 Other DX Units. Other DX units, including those that control space temperature by modulating the airflow to the space, shall comply with the requirements of Table E 503.5.3.1. [ASHRAE 90.1:6.5.1.46.5.1.3]

<table>
<thead>
<tr>
<th>RATING CAPACITY, (Btu/h)</th>
<th>MINIMUM NUMBER OF MECHANICAL COOLING STAGES</th>
<th>MINIMUM COMPRESSOR DISPLACEMENT*</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥65 000 and &lt;240 000</td>
<td>3</td>
<td>≥25% of full load</td>
</tr>
<tr>
<td>≥240 000</td>
<td>4</td>
<td>≥25% full load</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour ≥ 0.293 kW
* For mechanical cooling stage control that does not use variable compressor displacement the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

**TABLE E 503.5.1.2**
HIGH-LIMIT SHUTOFF CONTROL SETTINGS FOR AIR ECONOMIZERS
[ASHRAE 90.1: TABLE 6.5.1.1.3]

<table>
<thead>
<tr>
<th>CONTROL TYPE</th>
<th>ALLOWED ONLY IN CLIMATE ZONE AT LISTED SETPOINT</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHERE):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EQUATION</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>Fixed dry bulb temperature</td>
<td>$To_a &gt; 75^\circ F$</td>
<td>Outdoor air temperature exceeds $75^\circ F$</td>
</tr>
<tr>
<td></td>
<td>$To_a &gt; 70^\circ F$</td>
<td>Outdoor air temperature exceeds $70^\circ F$</td>
</tr>
<tr>
<td></td>
<td>$To_a &gt; 65^\circ F$</td>
<td>Outdoor air temperature exceeds $65^\circ F$</td>
</tr>
<tr>
<td>Differential dry bulb temperature</td>
<td>$To_a &gt; Tr_a$</td>
<td>Outdoor air temperature exceeds return air temperature</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**TABLE E 503.5.2**
WATER FLUID ECONOMIZER SIZING DRY-BULB AND WET-BULB REQUIREMENTS FOR COMPUTER ROOMS*
[ASHRAE 90.1: TABLE 6.5.1.2.1]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>EVAPORATIVE WATER ECONOMIZER WATER COOLED</th>
<th>DRY-COOLER-WATER ECONOMIZER AIR COOLED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRY BULB, °F</td>
<td>WET BULB, °F</td>
<td>DRY BULB, °F</td>
</tr>
<tr>
<td>0</td>
<td>A</td>
<td>NR</td>
</tr>
<tr>
<td>0</td>
<td>B</td>
<td>NR</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**E 503.5.4.1 Economizer Humidification System Impact.** Systems with hydronic cooling and humidification systems designed to maintain inside humidity at a dew-point temperature more than 35°F (2°C) shall use a water fluid economizer where an economizer is required in accordance with Section E 503.5 through Section E 503.5.4.1. [ASHRAE 90.1: 6.5.1.6, 6.5.1.5]

**E 503.5.5 Simultaneous Heating and Cooling Limitation, Zone Controls.** Zone thermostatic controls shall prevent the following:
(1) Reheating.
(2) Recooling.
(3) Mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems.
(4) Other simultaneous operation of heating and cooling systems to the same zone.

**Exceptions:**
(1) Zones without DDC for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:
   (a) Twenty percent of the zone design peak supply rate for systems with DDC and 30 percent for other systems.
   (b) The outdoor airflow rate required to be in accordance with the ventilation requirements of Chapter 4 or ASHRAE 62.1 for the zone.
   (c) A higher rate that is capable of demonstrating, to the satisfaction of the Authority Having Jurisdiction, to reduce overall system annual energy usage by offsetting reheat or recool energy losses through a reduction in outdoor air intake for the system.
(d) The airflow rate required to be in accordance with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.

(2) (remaining text unchanged)

(3) (remaining text unchanged)

(4) (remaining text unchanged) [ASHRAE 90.1:6.5.2.1]

E 503.5.5.2.3 Hydronic (Water Loop) Heat Pump Systems. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower) and heat addition (e.g., boiler) shall have the following:

(1) Controls that are capable of and configured to provide a heat pump water supply temperature dead band of not less than 20°F (11°C) between initiation of heat rejection and heat addition by the central devices (e.g., tower and boiler).

(2) (remaining text unchanged) [ASHRAE 90.1:6.5.2.2.3]

E 503.5.5.3 Dehumidification. Where humidity controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

Exceptions:

(1) The system is capable of and configured to reduce supply air volume to 50 percent or less of the design airflow rate or the minimum outdoor air ventilation rate in accordance with ASHRAE 62.1 or other applicable federal, state, or local code or recognized standard, whichever is larger before simultaneous heating and cooling takes place.

(2) The individual fan cooling unit has a design cooling capacity of not more than 65 000 Btu/h (19 kW) and is capable of and configured to unload to 50 percent capacity before simultaneous heating and cooling takes place.

(3) The individual mechanical cooling unit has a design cooling capacity of not more than 40 000 Btu/h (11.7 kW). An individual mechanical cooling unit is a single system composed of a fan or fans and a cooling coil capable of providing mechanical cooling.

(4) Systems serving spaces where specific humidity levels are required to satisfy process needs, such as vivariums, museums, surgical suites, pharmacies, and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses, and ice arenas, and where the building includes site-recovered energy or site-solar energy source that provide energy equal to 75 percent or more of the annual energy for reheating or for providing warm air in mixing systems. This exception shall not apply to computer rooms.

(5) Not less than 90 percent of the annual energy for reheating or for providing warm air in mixing systems is provided from a site-recovered energy (including condenser heat) or site-solar energy source.

(6) Systems where the heat added to the airstream is the result of the use of a desiccant system and 75 percent of the heat added by the desiccant system is removed by a heat exchanger, either before or after the desiccant system with energy recovery. [ASHRAE 90.1:6.5.2.3]

E 503.5.6 Air System Design and Control. HVAC air system design and control systems having a total fan system motor nameplate horsepower (hp) exceeding 5 hp (3.7 kW) shall be in accordance with the provisions of Section E 503.5.6.1 through Section E 503.5.6.5. [ASHRAE 90.1:6.5.3]

E 503.5.6.1 Fan System Power and Efficiency. Each HVAC systems at fan system design conditions shall not exceed the allowable having a total fan system motor nameplate horsepower (kW) exceeding 5 hp (3.7 kW) at fan system design conditions shall not exceed the allowable fan system motor nameplate horsepower (kW) (Option 1) or fan system brake horsepower (kW) (Option 2) as shown in Table E 503.5.6.1(1). This shall include supply fans, return or relief fans, exhaust fans, and fan-powered terminal units associated with systems providing heating or cooling capability that operate at fan system design conditions. Single-zone variable air volume VAV systems shall comply with the constant-volume fan power limitation.

Exceptions:

(1) Hospital, vivarium, and laboratory systems that utilize flow control devices on exhaust, return, or both to maintain space pressure relationships necessary for occupant health and safety, or environmental control shall be permitted to use variable-volume fan power limitation.

(2) Individual exhaust fans with motor nameplate horsepower of 1 hp (0.7 kW) or less. [ASHRAE 90.1:6.5.3.1.1]
TABLE E 503.5.6.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT
[ASHRAE 90.1: TABLE 6.5.3.1-2]

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully ducted return, exhaust, or both air systems: Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms</td>
<td>0.5 in. w.c. (2.15 in w.c. for laboratory and vivarium systems)</td>
</tr>
<tr>
<td>Energy recovery device, other than coil runaround loop</td>
<td>For each airstream [(2.2 x energy recovery effectiveness enthalpy recovery ratio) - 0.5] in w.c. for each airstream</td>
</tr>
</tbody>
</table>

(portion of table not shown remain unchanged)

**E 503.5.6.1.1 Motor Nameplate Horsepower.** For a **each** fan, the selected fan motor shall be not larger than the first available motor size more than the brake horsepower (bhp) (kW). The fan brake horsepower shall be indicated on the design documents to allow for compliance verification by the Authority Having Jurisdiction.

**Exceptions:**
(1) For fans less than 6 bhp (4.5 kW), where the first available motor larger than the bhp (kW) has a nameplate rating within 50 percent of the bhp (kW), the next larger nameplate motor size shall be selected.
(2) For fans 6 bhp (4.5 kW) and larger, where the first available motor larger than the bhp (kW) has a nameplate rating within 30 percent of the bhp (kW), the next larger nameplate motor size shall be selected.
(3) Systems that are in accordance with Section E 503.5.6.1, Option 1.
(4) Fans with motor nameplate horsepower of less than 1 hp (0.7 kW). [ASHRAE 90.1:6.5.3.1.2]

**E 503.5.6.1.2 Fan Efficiency.** Fans shall have a fan efficiency grade (FEG) of 67 or more, based on manufacturers' certified data in accordance with AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

**Exceptions:**
(1) **Single Individual** fans with a motor nameplate horsepower of 5 hp (3.7 kW) or less that are not part of a group operated as the functional equivalent of a single fan.
(2) through (7) remain unchanged

[ASHRAE 90.1:6.5.3.1.3]

**E 503.5.6.2.2 VAV Setpoint Reset.** For **multiple-zone VAV systems having a total fan system motor nameplate horsepower exceeding 5 hp (3.7 kW)** with DDC of individual zones reporting to the central control panel, static pressure setpoint shall be reset based on the zone requiring the most pressure, such as the setpoint is reset lower until one zone damper is nearly wide open. Controls shall provide the following:
(1) Monitor zone damper positions or other indicator of need for static pressure.
(2) Automatically detect those zones that are capable of excessively driving the reset logic and generate an alarm to the system operator.
(3) Readily allow operator removal of zone(s) from the reset algorithm. [ASHRAE 90.1:6.5.3.2.3]
TABLE E 503.5.6.2
EFFECTIVE DATES FOR FAN AIRFLOW CONTROL
[ASHRAE 90.1: TABLE 6.5.3.2.1]

<table>
<thead>
<tr>
<th>COOLING SYSTEM TYPE</th>
<th>FAN MOTOR SIZE, (hp)</th>
<th>MECHANICAL COOLING CAPACITY, (Btu/h)</th>
<th>EFFECTIVE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX cooling</td>
<td>Any</td>
<td>≥110,000 &gt; 65,000</td>
<td>1/1/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥75,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥65,000</td>
<td></td>
</tr>
<tr>
<td>Chilled-water and evaporative cooling</td>
<td>≥5</td>
<td>Any</td>
<td>1/1/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥1/4</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour ≥ 0.293 kW, 1 horsepower ≥ 0.746 kW, 1 cubic foot per minute ≥ 0.00047 m³/s

E 503.5.7.1 Hydronic Variable Flow Systems. HVAC pumping Chilled- and hot-water distribution systems that include three or more control valves designed to modulate or step open and close as a function of load shall be designed for variable fluid flow and shall be capable of and configured to reduce pump flow rates to not more than the larger of 25 50 percent or less of the design flow rate or the minimum flow required by the heating/cooling equipment manufacturer for the proper operation of equipment. Individual or parallel pumps serving variable-flow heating-water or chilled-water systems, where the nameplate horsepower of the motor or combined parallel motors is not less than the power shown in Table E503.5.7.1, 5 hp (3.7 kW) shall have controls or devices that will result in pump motor demand of not more than 30 percent of design wattage at 50 percent of design water flow. The controls or devices shall be controlled as a function of desired flow or to maintain a minimum required differential pressure. Differential pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure. The differential pressure setpoint shall not exceed 110 percent of that required to achieve design flow through the heat exchanger. Where differential pressure control is used to comply with this section, and DDC systems are used, the setpoint shall be reset downward based on valve positions until one valve is nearly wide open.

Exceptions:
1. Differential pressure set-point reset is not required where valve position is used to comply with Section E 503.5.7.3.
2. Variable-pump flow control is not required on heating-water pumps where more than 50 percent of annual heat is generated by an electric boiler.
3. Variable flow is not required for primary pumps in a primary/secondary system.
4. Variable flow is not required for a coil pump provided for freeze protection.
5. Variable flow is not required for heat recovery coil runaround loops. [ASHRAE 90.1:6.5.4.2]

TABLE E 503.5.7.1
PUMP FLOW CONTROL REQUIREMENTS
[ASHRAE 90.1: Table 6.5.4.2]

<table>
<thead>
<tr>
<th>CHILLED WATER PUMPS IN THESE CLIMATE ZONES</th>
<th>HEATING WATER PUMPS IN THESE CLIMATE ZONES</th>
<th>MOTOR NAMEPLATE HORSEPOWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A, 0B, 1A, 1B, 2B</td>
<td>NR</td>
<td>≥2 hp</td>
</tr>
<tr>
<td>2A, 3B</td>
<td>NR</td>
<td>≥3 hp</td>
</tr>
<tr>
<td>3A, 3C, 4A, 4B</td>
<td>7, 8</td>
<td>≥5 hp</td>
</tr>
<tr>
<td>4C, 5A, 5B, 5C, 6A, 6B</td>
<td>3C, 5A, 5C, 6A, 6B</td>
<td>≥7.5 hp</td>
</tr>
<tr>
<td></td>
<td>4A, 4C, 5B</td>
<td>≥10 hp</td>
</tr>
<tr>
<td></td>
<td>4B</td>
<td>≥15 hp</td>
</tr>
<tr>
<td></td>
<td>2A, 2B, 3A, 3B</td>
<td>≥25 hp</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>≥100 hp</td>
</tr>
<tr>
<td></td>
<td>0A, 0B, 1A</td>
<td>≥200 hp</td>
</tr>
</tbody>
</table>

For SI units: 1 horsepower ≥ 0.746 kW
### TABLE E 503.7.2
MINIMUM DUCT INSULATION R-VALUE¹
[ASHRAE 90.1: TABLE 6.8.2]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DUCT LOCATION</th>
<th>SUPPLY AND RETURN DUCTS FOR HEATING AND COOLING</th>
<th>SUPPLY AND RETURN DUCTS FOR HEATING ONLY</th>
<th>SUPPLY AND RETURN DUCTS FOR COOLING ONLY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EXTERIOR²</td>
<td>UNCONDITIONED SPACE AND BURIED DUCTS</td>
<td>INDIRECTLY CONDITIONED SPACE³, ⁴</td>
<td></td>
</tr>
<tr>
<td>0 to 4</td>
<td>R-8</td>
<td>3, 4</td>
<td>3, 4</td>
<td></td>
</tr>
<tr>
<td>5 to 8</td>
<td>R-12</td>
<td>3, 4</td>
<td>3, 4</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. Insulation R-values, measured in [°F•hr•ft²/(Btu•in)] [(m•K)/W], are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior walls, portions of the building envelope, a reused as a plenum walls, enclosure, wall building envelope, insulation shall be in accordance with the most restrictive condition of Table 6.8.2 or ASHRAE 90.1, depending on whether the plenum is located in the roof, wall, or floor. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F (24°C) at the installed thickness.

2. Includes attics above insulated ceilings, parking garages and crawl spaces.

3. Includes return air plenums, with or without exposed roofs above.

4. Return ducts in this duct location do not require insulation.

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**E 503.5.10 Exhaust Air Energy Recovery.** Each fan system shall have an energy recovery system where the design supply fan airflow rate exceeds the value listed in Table E 503.5.10(1) and Table E 503.5.10(2), based on the climate zone and percentage of outdoor airflow rate at design conditions. Table E 503.5.10(1) shall be used for all ventilation systems that operate less than 8000 hours per year and Table E 503.5.10(2) shall be used for all ventilation systems that operate 8000 or more hours per year.

Energy recovery systems required by this section shall result in an enthalpy recovery ratio of not less than 50 percent. A fifty percent energy enthalpy recovery effectiveness ratio shall be the mean change in the enthalpy of the outdoor air supply equal to 50 percent of the difference between the outdoor air and return entering exhaust air enthalpies at design conditions. Provision shall be provided to bypass or control the energy recovery system to permit air economizer operation in accordance with Section E 503.5.1.

### Exceptions:

1. Laboratory systems that are in accordance with Section E 503.5.11.3.
2. Systems serving spaces that are not cooled and that are heated to less than 60°F (16°C).
3. Where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy or site-solar energy.
4. Heating energy recovery in Climate Zones 0, 1, and 2.
5. Cooling energy recovery in climate zones 3c, 4c, 5bB, 5c, 6b, 7, and 8.
6. Where the sum of the airflow rates exhausted and relieved within 20 feet (6096 mm) of each other is less than 75 percent of the design outdoor airflow rate, excluding exhaust air that is
   (a) used for another energy recovery system,
   (b) not allowed by ASHRAE 170 for use in energy recovery systems with leakage potential,
(c) of Class 4 as defined in ASHRAE 62.1.
(§ 7) Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
(6 § 8) Systems expected to operate less than 20 hours per week at the outdoor air percentage in accordance with Table E 503.5.10(1).
[ASHRAE 90.1:6.5.6.1.1]

### TABLE E 503.5.10(1)

**EXHAUST AIR ENERGY RECOVERY REQUIREMENTS FOR VENTILATION SYSTEMS OPERATING LESS THAN 8000 HOURS PER YEAR**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE</th>
<th>DESIGN SUPPLY FAN AIRFLOW RATE (cubic feet per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥10% and &lt;20%</td>
<td>≥20% and &lt;30%</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥26 000</td>
<td>≥16 000</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥4500</td>
<td>≥4000</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

### TABLE E 503.5.10(2)

**EXHAUST AIR ENERGY RECOVERY REQUIREMENTS FOR VENTILATION SYSTEMS OPERATING NOT LESS THAN 8000 HOURS PER YEAR**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE</th>
<th>DESIGN SUPPLY FAN AIRFLOW RATE (cubic feet per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥10% and &lt;20%</td>
<td>≥20% and &lt;30%</td>
</tr>
<tr>
<td>0B, 1B, 2B, 3B, 4C, 5C</td>
<td>NR</td>
<td>≥19 500</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4B, 5B</td>
<td>≥2500</td>
<td>≥2000</td>
</tr>
<tr>
<td>4A, 5A, 6A, 6B, 7, 8</td>
<td>≥0</td>
<td>≥200</td>
</tr>
</tbody>
</table>

1 cubic foot per minute ≥ 0.00047 m³/s
* NR—Not required

**E 503.5.11.2.1 Kitchen or Dining Facility.** Where a kitchen or dining facility has a total kitchen hood exhaust airflow rate more than 5000 ft³/min (2.3597 m³/s), then one of the following shall be provided:

1. Fifty percent or more of all replacement air is transfer air that would otherwise be exhausted.
2. Demand ventilation system(s) provide on 75 percent or more of the exhaust air. Such systems shall be capable of and configured to provide 50 percent or more reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent, and combustion products during cooking and idle.
3. Listed energy recovery devices that result in a sensible heat recovery effectiveness ratio of 40 percent or more on 50 percent or more of the total exhaust airflow. A 40 percent sensible energy recovery ratio shall mean a change in the dry-bulb temperature of the outdoor air supply equal to 40 percent of the difference between the outdoor air and entering exhaust air dry-bulb temperatures at design conditions. [ASHRAE 90.1:6.5.7.2.3]
E 503.5.11.3 Laboratory Exhaust Systems. Buildings with laboratory exhaust systems having a total exhaust rate of more than 5000 ft$^3$/min (2.3597 m$^3$/s) shall include not less than one of the following features:

1. VAV laboratory exhaust and room supply systems capable of and configured to reduce exhaust airflow rates, and makeup airflow rates, or both incorporate a heat recovery system to precondition makeup air from laboratory exhaust, or both, and shall be in accordance with the following:

$$A + B(E/M) = 50\%$$  
(Equation E 503.5.11.3)

Where:

- $A =$ Percentage that the exhaust and makeup airflow rates are capable of being reduced from design conditions.
- $B =$ Sensible energy recovery effectiveness ratio.
- $E =$ Exhaust airflow rate through the heat recovery device at design conditions.
- $M =$ Makeup airflow rate of the system at design conditions.

2. VAV laboratory exhaust and room supply systems that are required to have minimum circulation rates to be in accordance with the codes or accreditation standards shall be capable of and configured to reduce zone exhaust and makeup airflow rates to the regulated minimum circulation values, or the minimum required to maintain pressurization relationship requirements. Systems serving nonregulated zones shall be capable of and configured to reduce exhaust and makeup airflow rates to 50 percent of the zone design values, or the minimum required to maintain pressurization relationship requirements.

3. Direct makeup (auxiliary) air supply of 75 percent or more of the exhaust airflow rate, heated not more than 2°F (1°C) below room setpoint, cooled to not less than 3°F (2°C) above room setpoint, no humidification added, and no simultaneous heating and cooling are used for dehumidification control. [ASHRAE 90.1:6.5.7.3]

SUBSTANTIATION:
Technical Merit: Current requirements in Appendix E were extracted from ASHRAE 90.1-2016. However, the provisions do not correlate completely with ASHRAE 90.1. During the cooling season vestibules do not serve a functional purpose if the setpoint for the vestibule is the same as the adjacent space. Allowing the air in the vestibule to be tempered by transfer air is beneficial because that air-conditioned space within the vestibule is destined to be exhausted. The modified provisions add vestibule limits for mechanical cooling to 85 degrees F when the vestibule is tempered with transfer air or heated with recovered energy. A detailed economic analysis was performed to justify the expanded requirements for the use of economizers using commercial HVAC; however, since there were no benchmark building defined requirements for computer rooms, the requirements from ASHRAE 90.1-2007 were used. Due to concerns about humidity control in computer rooms and having to humidify the outside free cooling air, the use of economizers was cut off when the ambient wet-bulb was below 35°F wb. Using the data and the cost model developed for the justification of ASHRAE 90.1-2007, the scalar economic analysis was updated using the new economic criteria developed for the 2013 to 2016 ASHRAE 90.1 cycle. One can justify the elimination of the computer room economizer size criteria, and the use of the HVAC economizer table for all products can easily be justified. As such, ASHRAE 90.1-2016 eliminates Table 6.5.1-2 and requires that table 6.5.1-1 be used for both HVAC and computer room units. See ASHRAE 90.1-2013 addendum “i” for more details. Other updates include changing “water economizer” to “fluid economizer” to account for refrigerant-based economizers and adding requirements for Climate Zone 0. Emergency nature: The emergency nature of this proposed TIA is supported by Section 5-2(a) of the Regulations Governing Committee Projects. “The document contains an error or an omission that was overlooked during a regular revision process.” The current Uniform Mechanical Code does not provide the exception to limit the mechanical cooling in vestibules to 85 degrees F when the vestibule is tempered with transfer air or heated with recovered energy. Furthermore, the current Mechanical Code currently has a separate table for indicating when an economizer is required for computer rooms and will conflict the latest requirements of ASHRAE 90.1-2016, latest edition, which now uses “one” table to determine when economizers are needed.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 155

UMC 2021  Section: E 505.5, E 505.6, Table 1701.2

SUBMITTER: Jeremy Brown
NSF International

RECOMMENDATION:
Revise text

TABLE E 505.5
PLASTIC GROUND SOURCE LOOP PIPING

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM F2623; ASTM F2769, NSF 358-4</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

TABLE E 505.6
GROUND SOURCE LOOP PIPE FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM D3261; ASTM F1807; ASTM F2159; ASTM F2769; CSA B137.1, NSF 358-4</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

TABLE 1701.2
STANDARD, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF 358-4 (Draft)</td>
<td>Polyethylene of Raised Temperature (PE-RT) Pipe and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems</td>
<td>Piping, Plastic</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

Note: NSF 358-4 is a working draft and is not completed at the time of this monograph.

SUBSTANTIATION:
NSF 358-4 Polyethylene of Raised Temperature (PE-RT) Pipe and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems. This standard is the 4th in a series of standard for geothermal pipe and fittings. NSF 358-1 (PE), 358-2 (PP), 358-3(PEX) are already referenced in the UMC. This last version is adding the requirements for PE-RT. This standard addresses requirements for performance, long term strength, U-bend assembled joint testing, chemical resistance, thermocycling, constant tensile load joint testing, joint pressure testing, marking, suitability for burial and quality assurance. A balloted draft version of this document will be submitted with this proposal and the final published version will be available in advance of the Technical Committee Meeting. Anyone wanting a copy of NSF 358-4 for the purposes of considering this proposal may request a free copy from brown@nsf.org

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed text is being rejected as NSF 358-4 was a working draft and was not completed at the time of the monograph.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 24  NEGATIVE: 1  NOT RETURNED: 1  HOWARD

EXPLANATION OF AFFIRMATIVE:

MANN: This Standard may be published now but this committee has never accepted a Standard that is a working draft at the time of the UMC Committee Meeting. This can be submitted next year and debated at that time.

EXPLANATION OF NEGATIVE:

MACNEVIN: NSF 358-4 has since been published and made available to the TC. NSF 358-4 is appropriate for this product in these tables.
E 605.0 Indoor Air Quality for Low-Rise Residential.

**E 605.1.3.2 Effective Annual Average Infiltration Rate (Q_{inf}).** Effective Annual Average Infiltration Rate (Q_{inf}) shall be calculated using Equation E 605.1.3.2:

\[ Q_{inf} (\text{cfm}) = \left( \frac{NL \times wsf \times A_{floor}}{(7.3)^*} \right) \]  

Where:
- NL = normalized leakage
- wsf = weather and shielding factor from ASHRAE 62.2
- A_{floor} = floor area of residence, ft^2 (m^2)
- * Replace 7.3 with 1.44 for metric units. [ASHRAE 62.2:4.1.2(e)]

**E 605.1.3.3 Required Mechanical Ventilation Rate (Q_{fan}).** Required Mechanical Ventilation Rate (Q_{fan}) shall be calculated using Equation E 605.1.3.3:

\[ Q_{fan} = Q_{tot} - (Q_{inf} \times A_{ext}) \]  

Where:
- Q_{fan} = required mechanical ventilation rate, cfm (L/s)
- Q_{tot} = total required ventilation rate, cfm (L/s)
- Q_{inf} = may be not greater than 2/3 \times Q_{tot} (see ASHRAE 62.2 for exceptions for existing buildings)
- A_{ext} = 1 for single-family detached homes, or the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to total envelope surface area for single-family attached homes. [ASHRAE 62.2:4.1.2(f)]

**E 605.1.7 Variable Mechanical Ventilation.** Dwelling-unit mechanical ventilation systems designed to provide variable ventilation shall comply with Section E 605.1.7.1 or Section E 605.1.7.2 or ASHRAE 62.2 Section E 605.1.7.3. Section E 605.1.7.2 and ASHRAE 62.2 Section E 605.1.7.3 also require compliance with ASHRAE 62.2 and require verification with supporting documentation from the manufacturer, designer, or specifier of the ventilation control system that the system meets the requirements of these sections. Where the dwelling-unit ventilation rate varies based on occupancy, occupancy shall be determined by occupancy sensors or by an occupant-programmable schedule. [ASHRAE 62.2:4.5]

**E 605.1.7.1 Short-Term Average Ventilation.** To comply with this section, a variable ventilation system shall be installed to provide an average dwelling-unit ventilation rate over any three-hour period that is greater than or equal to Q_{fan} as determined in accordance with ASHRAE 62.2 Section E 605.1.3.3. [ASHRAE 62.2:4.5.1]

**E 605.1.7.2 Scheduled Ventilation.** This section shall only be allowed to be used where one or more fixed patterns of designed ventilation are known at the time compliance to ASHRAE 62.2 Section E 605.0 is being determined. Such patterns include those both clock-driven and driven by typical meteorological data. Compliance with this section shall be in accordance with ASHRAE 62.2 either Section E 605.1.7.2.1 or Section E 605.1.7.2.2. [ASHRAE 62.2:4.5.2]

**E 605.1.7.2.1 Annual Average Schedule.** An annual schedule of ventilation complies with this section when the annual average relative exposure during occupied periods is not more than unity as calculated in accordance with ASHRAE 62.2. [ASHRAE 62.2:4.5.2.1]
E 605.1.7.2.2 Block Scheduling. The schedule of ventilation complies with this section when it is broken into blocks of time and each block individually has an average relative exposure during occupied periods that is not more than unity as calculated in ASHRAE 62.2. [ASHRAE 62.2:4.5.2.2]

E 605.1.7.3 Real-Time Control. A real-time ventilation controller complies with this section when it is designed to adjust the ventilation system based on real-time input to the ventilation calculations so that the average relative exposure during occupied periods is not more than unity as calculated in ASHRAE 62.2. The averaging period shall be not less than one day but not more than one year and shall be based on simple, recursive or running average, but not extrapolation. [ASHRAE 62.2:4.5.3]

SUBSTANTIATION:
Technical Merit: Current requirements in Appendix E were extracted from ASHRAE 62.2-2016. However, the provisions do not correlate completely with ASHRAE 62.2. The extract update modifies the provisions for “required mechanical ventilation” (Qfan) as the value for Qfan was previously removed without being replaced. Emergency nature: The emergency nature of this proposed TIA is supported by Section 5-2(a) of the Regulations Governing Committee Projects, “The document contains an error or an omission that was overlooked during a regular revision process.” Furthermore, the current Mechanical Code has values for Qfan that will conflict with the latest requirements of ASHRAE 62.2-2016, latest edition, which now uses different values for the required mechanical fan ventilation.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
SUBMITTER: Anneliese Khalil
Khalil Concepts

RECOMMENDATION:
Add new text

E 605.0 Indoor Air Quality for Low-Rise Residential.

E 605.2 Bathroom Exhaust Fans. (remaining text unchanged)

E 605.2.1 Venting Through a Soffit. All mechanical exhaust fans in rooms containing a bathtub, shower, or tub/shower combinations, when vented to the exterior through the soffit, shall be attached to a soffit vent termination that effectively displaces the exhausted air outside of the soffit's passive air stream.

SUBSTANTIATION:
Problem: Venting a bathroom exhaust fan through a soffit is one of the most common methods of venting. While it is an effective method of displacing moisture out of the home; it is not an effective method of inhibiting moisture from flowing back into the attic. Effective moisture displacement subscribes to effective removal as well as inhibiting reentry into the structure. Effective displacement of moisture helps prevent mold growth, structural damage and potential health and safety issues related to poor indoor air quality. Resolution: Require the use of a soffit vent termination that effectively displaces the exhausted bathroom fan air out of the soffit's passive air stream, which will inhibit the exhaust air from circulating back into the attic. The information below was provided by Richard Schofel, CEO of Moisture Flow Manufacturing, LLC: Attached are a few links of documented reports from qualified companies that talk about the problem of mold and what it costs each year. The problem is nobody has ever paid attention to them until they were confronted with the problem. For the past 40 years the major concern was on the remediation of the problem BUT NEVER on treating the cause. The Soffit Vent targets the cause! https://www.gotmold.ca/2012/10/mold-damage-costs-more-than-half-a-trillion-dollars-per-year/ Attached is a short video that I had made. This was the original Soffit Vent that was done and I changed the entire design and the material. Certain statement were made concerning being endorsed by the EPA that is not true. They are not allow to endorse any product. What is important is information in beginning. https://drive.google.com/file/d/14nC6is_gcwNQs5swE7Bgaex9LudHUc_L/view

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change was rejected as it contains proprietary requirements.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
E 605.0 Indoor Air Quality for Low-Rise Residential.

E 605.1.3 Dwelling-Unit Ventilation. A Mechanical exhaust system, supply system, or combination thereof shall be installed to operate for each dwelling unit to provide continuous dwelling-unit ventilation with outdoor air at a rate not less than the rate specified in Section E 605.1.3.1. [ASHRAE 62.2:4.1]

E 605.1.3.1 Total Ventilation Rate. The total required ventilation rate \( Q_{tot} \) shall be as specified in Table E 605.1.3.1 or, alternatively, calculated using Equation E 605.1.3.1.

\[
Q_{tot} = 0.03 A_{floor} + 7.5(N_{br} + 1)
\]

Where:
- \( Q_{tot} \) = total required ventilation rate, cfm cubic feet per minute (ft\(^3\)/min)
- \( A_{floor} \) = dwelling unit floor area, square foot (ft\(^2\))
- \( N_{br} \) = number of bedrooms; (not to be less than one)

For SI units: 1 cubic foot per minute = 0.00047 m\(^3\)/s, 1 square foot = 0.0929 m\(^2\)

Exceptions: Dwelling-unit mechanical ventilation systems shall be not be required where if the Authority Having Jurisdiction determines that window operation is a locally permissible method of providing ventilation and provided that a least one or more of the following conditions is met:
1. The building has no mechanical cooling and is located in zone 1 or 2 of the climate zone map.
2. The building is thermally conditioned for human occupancy for less than 876 hours per year. [ASHRAE 62.2:4.1.1]

E 605.1.3.4 Different Occupant Density. Table E 605.1.3.1 and Equation E 605.1.3.1 assume two persons in a studio or one-bedroom dwelling unit and an additional person for each additional bedroom. Where higher occupant densities are known, the rate shall be increased by 7.5 ft\(^3\)/min (0.003 m\(^3\)/s) for each additional person. Where approved by the Authority Having Jurisdiction, lower occupant densities shall be permitted may to be used. [ASHRAE 62.2:4.1.3]

E 605.1.4 System Type. The dwelling-unit mechanical ventilation system shall consist of one or more supply or exhaust fans and associated ducts and controls. Local exhaust fans shall be permitted to be part of a mechanical exhaust system. Where local exhaust fans are used to provide dwelling-unit ventilation, the local exhaust airflow shall be permitted may to be credited towards the whole dwelling-unit ventilation airflow requirement. Outdoor air ducts connected to the return side of an air handler shall be permitted as supply ventilation where manufacturer’s requirements for return air temperature are met. See ASHRAE 62.2 for guidance on selection of methods. [ASHRAE 62.2:4.2]

E 605.1.5 Airflow Measurement. The airflow required by this section shall be is the quantity of outdoor ventilation air supply, supplied and/or indoor air, or both exhausted by the mechanical ventilation system as installed and shall be measured according to the ventilation equipment manufacturer’s instructions, or by using a flow hood, flow grid, or other airflow measuring device at the mechanical ventilation fan’s inlet terminals/grilles, outlet terminals/grilles, or in the connected ventilation ducts. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to be in accordance with meet this section. [ASHRAE 62.2:4.3]

E 605.1.7.1 Short-Term Average Ventilation. To comply with this section, a variable ventilation system shall be installed to provide an average dwelling-unit ventilation rate over any three-hour period that is greater than or equal to \( Q_{fan} \) as determined in
accordance with calculated using Section E 605.1.3.3. [ASHRAE 62.2:4.5.1]

E 605.1.7.2 Scheduled Ventilation. This section shall may only be allowed to be used where when one or more fixed patterns of designed ventilation are known at the time compliance to Section E 605.0 is being determined. Such patterns include those both clock-driven and driven by typical meteorological data. Compliance with this section shall can be in accordance demonstrated with either Section E 605.1.7.2.1 or Section E 605.1.7.2.2. [ASHRAE 62.2:4.5.2]

E 605.1.7.2.1 Annual Average Schedule. An annual schedule of ventilation complies with this section when the annual average relative exposure during occupied periods is not no more than unity as calculated in accordance with ASHRAE 62.2. [ASHRAE 62.2:4.5.2.1]

E 605.1.7.2.2 Block Scheduling. The schedule of ventilation complies with this section when if it is broken into blocks of time and each block individually has an average relative exposure during occupied periods that is not no more than unity as calculated in ASHRAE 62.2. [ASHRAE 62.2:4.5.2.2]

E 605.1.7.3 Real-Time Control. A real-time ventilation controller complies with this section when it is designed to adjust the ventilation system based on real-time input to the ventilation calculations so that the average relative exposure during occupied periods is not no more than unity as calculated in ASHRAE 62.2. The averaging period shall be not less than at least one day but not no more than one year and shall be based on simple, recursive or running average, but not extrapolation. [ASHRAE 62.2:4.5.3]

E 605.1.8 Equivalent Ventilation. A dwelling-unit ventilation system shall be designed and operated in such a way as to provide the same or lower annual exposure as would be provided in accordance by complying with Section E 605.1.3. The calculations shall be based on a single zone with a constant contaminant emission rate. The manufacturer, specifier, or designer of the equivalent ventilation system shall certify that the system is in accordance with meets this intent and provide supporting documentation. [ASHRAE 62.2:4.6]

SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Appendix E has been revised to correlate with the latest ASHRAE 62.2-2016.

COMMITTEE ACTION: REJECT

COMMITTEE STATEMENT:
The proposed change removes mandatory enforceable language.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
209.0 – G –

**Geothermal Energy System.** A system that uses thermal energy for space heating and cooling, and water heating.

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

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

**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.

**Groundwater Source.** A geothermal energy system that uses the groundwater as a heat source or sink.

210.0 – H –

**Hydronic System.** Relating to, or being a system of, heating or cooling that involves the transfer of heat by a circulating fluid (such as water or vapor).

**Part I Closed-Loop Systems**

**F 101.0 General.**

**F 101.1 Applicability.** Part I of this appendix shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a ground-heat exchanger, submerged heat exchanger or groundwater (well) using water-based fluid as a heat transfer medium. The regulations of this appendix 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 F 103.7 and Chapter 12.

**F 101.1.1 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.

**F 101.1.2 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.

**F 101.2 Construction Documents.** The construction documents for the building system portion of the geothermal energy system shall be submitted to the Authority Having Jurisdiction.

**F 101.3 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:

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.
Chapter 2

Definitions

209.0  –  G –

Geothermal Energy System.  A system that uses thermal energy for space heating and cooling, and water heating.

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

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

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 source or sink for heat.
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.

**Groundwater Source.** A geothermal energy system that uses the groundwater as a heat source or sink.

**210.0 – H –**

**Hydronic System.** Relating to, or being a system of heating or cooling that involves the transfer of heat by a circulating fluid (such as water or vapor).

---

**APPENDIX F**

**GEOTHERMAL ENERGY SYSTEMS**

**Part I Closed-Loop Systems**

F 101.0 General.

F 101.1 Applicability. Part I of this appendix shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a ground-heat exchanger, submerged heat exchanger or groundwater (well) using water-based fluid as a heat transfer medium. The regulations of this appendix 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 F 103.7 and Chapter 12.

F 101.1.1 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.

F 101.1.2 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.

F 101.2 Definitions.

**Geothermal Energy System.** A system that uses thermal energy for space heating and cooling, and water heating.

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

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

**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.

**Groundwater Source.** A geothermal energy system that uses the groundwater as a heat source or sink.

(renumber remaining sections)

F 101.2 Construction Documents. The construction documents for the building system portion of the geothermal energy system shall be submitted to the Authority Having Jurisdiction.

F 101.3 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:

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.

F 101.4 Decommissioning and Abandonment. Prior to the abandonment or decommissioning of a ground-heat exchanger, submerged heat exchanger or ground water (well) the owner shall obtain the necessary permits from the Authority Having Jurisdiction.

F 101.5 Used Materials. The installation of used pipe, fittings, valves, and other materials shall not be permitted.

F 101.6 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.

F 101.7 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.

F 101.8 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.

F 101.9 Pipe Support. Pipe shall be supported in accordance with Section 313.1.

F 101.10 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.
F 101.11 Chemical Compatibility. Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings, and mechanical systems.

F 101.12 Transfer Fluid. The transfer fluid shall be compatible with the makeup water supplied to the system.

APPENDIX FG
SIZING OF VENTING SYSTEMS AND OUTDOOR COMBUSTION AND VENTILATION OPENING DESIGN

APPENDIX GH
EXAMPLE CALCULATION OF OUTDOOR AIR RATE

COMMITTEE STATEMENT:
The proposed modification clarifies that this is a new Appendix F and the remaining appendices will be renumbered/relettered accordingly. Furthermore, some of the definitions are being relocated from Chapter 2 to the new Appendix F.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 160

UMC 2021  Section: F 102.0 - F 102.1.2, Table 1701.2

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

**F 102.0 Groundwater Systems.**

**F 102.1 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.

**F 102.1.1 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 tested for water production and recovery. Monitoring wells shall be protected, and marked to allow for monitoring of ground temperature, groundwater levels, and groundwater quality.

**F 102.1.2 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.

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>NGWA-01-2014</td>
<td>Water Well Construction</td>
<td>Wells</td>
</tr>
</tbody>
</table>

(PORTION OF TABLE NOT SHOWN REMAINS UNCHANGED)

**SUBSTANTIATION:**
Clarification has been made that if a single water well is providing both potable water and heat exchange water, then backflow prevention is already covered by the code. Tests must be performed for both water flow and water quality. To gain information about the producing aquifer water flow, drawdown at other points in the area of the well, future drawdown and influences on other wells, a multi-well test is recommended. In this test, the production well is pumped at a controlled rate, and at least one nearby well is monitored for water level for a minimum of 24 hours. The purpose of water quality testing is to determine the chemical nature of the water, and its impact upon system materials selection and maintenance requirements. Water quality testing can be a critical part of the well testing phase if unusual or problem water chemistry is suspected. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
F 103.0 Design of Systems.
F 103.1 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.
F 103.2 Installation Practices. A ground-heat exchanger system shall be installed as follows:

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. Vertical and horizontal ground-heat exchangers shall maintain the following setbacks:
   a. Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
   b. Twenty feet (6096 mm) horizontally from a non-pressure tested sewer lateral into a building.
   c. Three feet (914 mm) horizontally from buried utilities such as electrical, gas, or water.
   d. Fifty feet (15 240 mm) from a water well.
   e. Fifty feet (15 240 mm) from a septic tank and 100 feet (30 480 mm) from a subsurface sewage leaching field.
   f. One hundred feet (30 480 mm) from a spring; 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.

SUBSTANTIATION:
Sizing of the ground-heat exchanger may be accomplished with one of the many computer programs available, or from heating and cooling design loads, energy loads and ground loads. The type of system to be installed is based on the available land area and the geotechnical survey at the site before the ground loop is designed. In addition, specifications need to address the total ground coil length, minimum bore separation distance, and U-tube diameter to ensure acceptable maximum and minimum liquid loop temperatures during the life of the system. This information will allow the designer to specify heat pump equipment that will operate efficiently and specify pumps for the ground and building piping loops which have adequate flow in order to ensure effective heat transfer without creating unacceptable head losses and the resulting excessive pumping energy consumption. Lastly, a layout must be designed that can be purged of air and debris, is balanced within 15% without flow regulators, and is connected in a minimum number of trenches or pits. Piping must be protected from freezing. Where piping is installed in an exterior wall or ceiling of a space intended for occupancy (in other words, a heated space), some degree of freeze protection can be achieved by making sure that the thermal insulation for the wall (or ceiling) is installed between the outdoor surface and the piping. Whether or not this arrangement will prevent freezing temperatures at the piping location depends on the climatic conditions, the thickness of insulation (between the outdoor surface and the piping) and the room temperature. Note, there must always be a heat source along with an appropriate insulation thickness to protect pipes from freezing conditions. Insulation by itself (without a heat source) cannot protect a pipe from freezing; insulation only slows the rate of heat loss. The distance between the supply and return pipe should be defined by a heat transfer calculation which accounts for the size of the pipe, the differential temperature and the location of the pipe. Buried pipe between the ground heat exchanger and the building is never insulated. The purpose of a ground heat exchanger is to transfer heat to and from the earth, and insulation will prevent this heat transfer. Allow for submerged heat exchangers to be secured to a pier or dock foundation. Consistent with industry practices for grout emplacement. Reference IGSHPA, Section 2. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
**F 103.3 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. For direct exchange (DX) systems, each u-bend shall be tested and proved tight with an inert gas at not less than 315 psi (2172 kPa) and maintained for 15 minutes without pressure drop. The pressure reading after tremie grouting of the boreholes shall be maintained in the ground heat exchanger for not less than 2 hours, in accordance with CSA C448.

**F 103.4 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. CSA 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.

**F 103.4.1 Backfill.** Bentonite grout and thermally-enhanced bentonite grout, where used to seal and backfill each borehole, shall comply with NSF 60. Boreholes shall be backfilled in accordance with the Authority Having Jurisdiction.

**F 103.4.2 U-Bends and Header.** Headers, u-bends and ground loop pipes shall be pressure-tested in accordance with CSA 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.

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>NSF 60-2016</td>
<td>Drinking Water Treatment Chemicals - Health Effects</td>
<td>Miscellaneous</td>
</tr>
</tbody>
</table>

(subportion of table not shown remains unchanged)

**SUBSTANTIATION:**
The installation of vertical ground loops requires that the installation of a leak-free loop and backfill of the loop-to-bore annulus to ensure good heat transfer to the ground and groundwater protection. U-tubes can be manufactured by the pipe manufacturer with automated equipment at the factory. Vertical bores must be drilled to sufficient depths to ensure that the entire length of the U-tube is inserted. Also, the annular space between the tubing and borehole wall must be completely filled to ensure good heat transfer from the loop to the ground and to prevent flow of contaminated water from the surface to the groundwater. To reduce thermal interference between boreholes, a recommended separation distance of 20 feet is required. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** 
AFFIRMATIVE: 25  
NOT RETURNED: 1  
HOWARD
Item #: 163
UMC 2021  Section: F 103.4.2.1 - F 103.4.2.4

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

F 103.4.2.1 Test Pressure. The maximum test pressure shall be 1.5 times the system design pressure, as determined by Section F 103.4.2.3, or Section F 103.4.2.4, not to exceed 100 psi (689 kPa). Components or devices with lower pressure-ratings than the pipe shall be protected from excessive pressure during testing by removing or isolating from the test section.
Exception: Where lower pressure-rated components or devices cannot be removed or isolated from the test section, the maximum test pressure shall not exceed the pressure rating of the component or device.

F 103.4.2.2 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 make-up 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 make-up 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.

F 103.4.2.3 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.

F 103.4.2.4 Calculation of Static Pressure (Other Fluids). For fluids of different density, the static pressure shall be calculated using the density of the system fluid.

SUBSTANTIATION:
This section covers pipe joining and testing of the ground heat exchanger section of geothermal systems and has been added to better reflect the actual flow of work. The relevant sections of industry standard CSA C448 are addressed in this modified language, and the testing procedure is described in detail to make the process comprehensive and enforceable. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

**E.505.5 F.103.5 Piping and Tubing Materials Standards.** For water-based systems, ground source heat pump ground-loop pipe and tubing shall comply with the standards listed in Table **E.505.5 F.103.5. Piping and tubing used for DX systems shall be of copper in accordance with Section F.103.8.**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F441; ASTM F442</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F876; ASTMD E872; CSA B137.5; NSF 358-3, CSA C448</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe</td>
<td>ASTM F1282; CSA B137.9</td>
</tr>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2737; ASTM D3035; ASTM F714; AWWA C901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC)</td>
<td>ASTM D1785; ASTM D2244</td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM F2623; ASTM F2769, CSA B137.18, NSF 358-4, CSA C448</td>
</tr>
</tbody>
</table>

**E.505.6 F.103.6 Fittings.** For water-based systems, fittings for ground source heat pump systems shall be approved for installation with the piping materials to be installed, and shall comply with the standards listed in Table **E.505.6 F.103.6. Fittings for use in DX systems shall comply with Section F.103.8.**

<table>
<thead>
<tr>
<th>MATERIAL</th>
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<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F437; ASTM F438; ASTM F439; ASTM F1970; CSA B137.6</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F877; ASTM F1807; ASTM F1960; ASTM F2080; ASTM F2159; ASTM F2434; CSAB137.5; NSF 358-3, CSA C448, ASTM F.1055</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE)</td>
<td>ASTM F1282; ASTM F2434; CSAB137.9</td>
</tr>
</tbody>
</table>
### F 103.7 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 F 103.7.1 and Section F 103.7.1.1, or cross-linked polyethylene (PEX) pipe or tubing in accordance with Section F 103.7.2 and Section F 103.7.2.1.

#### F 103.7.1 Polyethylene (PE)

Polyethylene pipe or tubing shall be manufactured in accordance with the standards listed in Table F 103.5. Pipe or tubing shall have a maximum dimension ratio of 11 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Polyethylene pipe and 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 F 103.5, 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.

#### F 103.7.1.1 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 F 103.6, 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.

#### F 103.7.2 Cross-Linked Polyethylene (PEX)

Cross-linked polyethylene pipe shall be manufactured in accordance with the standards listed in Table F103.6. 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).

#### F 103.7.2.1 Joining Methods for Cross-Linked Polyethylene Tubing

Joints between cross-linked polyethylene (PEX) tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions and the appropriate standards in accordance with Table F 103.6.

#### F 103.8 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.

#### F 103.9 Indoor Piping

Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Chapter 12. Such materials shall be rated for the operating temperature and pressures of the system and shall be compatible with the type of transfer medium. For DX systems, joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8.

### TABLE 1701.2

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>NSF 358-4 (Draft)</td>
<td>Polyethylene of Raised Temperature (PE-RT) Pipe and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems</td>
<td>Ground-Source Heat Pumps</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**Note:** NSF 358-4 is a working draft and is not completed at the time of this monograph.

**SUBSTANTIATION:**

Piping, fittings and joints must be compatible with the heat transfer fluid, antifreeze (or the refrigerant in the case of direct exchange systems) and corrosion resistant. Piping is divided into underground piping for geothermal applications and indoor piping. In accordance with ASHRAE, Chapter 34 Geothermal Systems, carbon steel piping has shown good service in several systems as long as the system design excluded oxygen. However, the introduction of 0.03 mg/kg oxygen under turbulent flow conditions causes a fourfold increase in uniform corrosion. Saturation with air often increases the corrosion rate by at least 15 times. Oxygen contamination at the 0.05 mg/kg level causes severe pitting and chronic oxygen contamination causes rapid failure. External surfaces of buried steel pipe must be protected from contact with groundwater. Groundwater is aerated and has caused pipe failures by external corrosion. External protection can be obtained by coatings, wraps provided the selected material resists the system operating conditions.
Carbon steel piping is primarily used on the inside or clean loop side of the isolation heat exchanger. In both underground and aboveground installations, allowance for expansion joints or loops must be provided. For these reasons, carbon steel is not recommended for underground piping, but may be used as an acceptable indoor piping material. Copper-tubed fan-coil units and heat exchangers have consistently poor performance because of traces of sulfide species found in geothermal fluids in the United States. Copper tubing rapidly becomes fouled with cuprous sulfide films more than .04 mm thick. Serious crevice corrosion occurs at cracks in the film, and uniform corrosion rates of 50 to 150 mils per year appear typical, based on failure analysis. Copper pipe shows corrosion behavior similar to copper heat exchange tubes under conditions of moderate turbulence. Copper is not recommended for use in systems where it is exposed to the geothermal fluid (underground or indoor piping). This section does not apply to DX systems as the refrigerator is an inert gas - it does not cause electrolysis, so it will not corrode from the inside. Unlike copper and cupronickel, stainless steels are not affected by traces of hydrogen sulfide. Most heat exchangers are of the plate and frame type, most of which are fabricated with one of two standard alloys, Type 304 and Type 316 austenitic stainless steel. Some pump and valve trim also are fabricated from these or other stainless steels. These alloys are subject to pitting and crevice corrosion above a threshold chloride level, which depends on the chromium and molybdenum content of the alloy and on the temperature of the geothermal fluid. At elevated temperatures, the passivation film, which gives the stainless steel its corrosion resistance, is ruptured, and local pit and crevice corrosion occur. Type 304 is resistant at that temperature until the chloride level reaches approximately 510 mg/kg. Because of its 2% to 3% molybdenum content, Type 316 is always more resistant to chlorides than is Type 304. Stainless steel is recommended for the interior piping portion. Aluminum alloys are not acceptable in most cases because of catastrophic pitting. CPVC and PVC materials are easily fabricated and are not adversely affected by oxygen intrusion. External protection against groundwater is not required. The mechanical properties of these materials at higher temperatures may vary greatly from those at ambient temperature, and the materials' mechanical limits should not be exceeded. The usual mode of failure is creep rupture: strength decays with time. Manufacturer's directions for joining should be followed to avoid premature failure of joints. CPVC and PVC are not recommended for underground piping of the ground heat exchanger. However, CPVC and PEX have been used for the interior piping portions. Cross-linked polyethylene (PEX) is a high-density polyethylene material in which the individual molecules are “cross-linked” during the production of the material. The effect of the crosslinking imparts physical qualities to the piping which allow it to meet the requirements of much higher temperature/pressure applications. Joining the piping is accomplished using specially designed, conversion fittings which are generally of brass construction. Piping with and without an oxygen diffusion barrier is available. The oxygen barrier prevents the diffusion of oxygen through the piping wall and into the water. This is necessary corrosion prevention for closed systems in which ferrous materials are included. PEX is used for underground and indoor piping. Polyethylene (PE) is a flexible material available in a wide variety of sizes. This is the most common type of piping materials for underground portion of a ground source heat pump. Standard dimension ratio (SDR) is the ratio of the pipe outside diameter to the wall thickness and relates to the pressure rating of the pipe. SDR 17 is generally rated at 100 psi for all diameters, SDR 11 is rated at 160 psi, and SDR 9 is rated at 200 psi. The only recommended joining method is by thermal fusion. Polyethylene is recommended for underground and indoor piping.

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

Amend proposal as follows:

**F 103.5 Piping and Tubing Materials Standards.** For water-based systems, ground source heat pump ground-loop pipe and tubing shall comply with the standards listed in Table F 103.5. Piping and tubing used for DX systems shall be of copper in accordance with Section F 103.8.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F876; CSA B137.5; NSF 358-3, CSA C448</td>
</tr>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2737; ASTM D3035; ASTM F714; AWWAC901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM F2623; ASTM F2769, CSA B137.18; NSF 358-4, CSA C448</td>
</tr>
</tbody>
</table>

**F 103.6 Fittings.** For water-based systems, fittings for ground source heat pump systems shall be approved for installation with the piping materials to be installed, and shall comply with the standards listed in Table F 103.6. Fittings for use in DX systems shall comply with Section F 103.8.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F877; ASTM F1807; ASTM F1960; ASTM F2080; ASTM F2159; ASTM F2434; CSAB137.5; NSF 358-3, CSA C448, ASTM F 1055</td>
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<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389; CSA B137.11, NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM D3261; ASTM F1807; ASTM F2159; ASTM</td>
</tr>
</tbody>
</table>
F 103.7 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 F 103.7.1 and Section F 103.7.1.1, or cross-linked polyethylene (PEX) pipe or tubing in accordance with Section F 103.7.2 and Section F 103.7.2.1.

F 103.7.1 Polyethylene (PE). Polyethylene pipe or tubing shall be manufactured in accordance with the standards listed in Table F 103.5. Pipe or tubing shall have a maximum dimension ratio of 11 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Polyethylene pipe and 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 F 103.5, 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.

F 103.7.1.1 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 F 103.6, 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.

F 103.7.2 Cross-Linked Polyethylene (PEX). Cross-linked polyethylene pipe shall be manufactured in accordance with the standards listed in Table F103.6. 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).

F 103.7.2.1 Joining Methods for Cross-Linked Polyethylene Tubing. Joints between cross-linked polyethylene (PEX) tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions and the appropriate standards in accordance with Table F 103.6.

F 103.8 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.

F 103.9 Indoor Piping. Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Chapter 12. Such materials shall be rated for the operating temperature and pressures of the system and shall be compatible with the type of transfer medium. For DX systems, joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8.

### TABLE 1701.2

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF 358-4 (Draft)</td>
<td>Polyethylene of Raised Temperature (PE-RT) Pipe and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems</td>
<td>Ground-Source Heat Pumps</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

COMMITTEE STATEMENT:
The proposed text is being modified to remove reference to NSF 358-4 as it was a working draft and was not completed at the time of the monograph.

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 165

UMC 2021  Section: F 104.0 - F 105.4

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

**F 104.0 Installation.**

**F 104.1 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.

**F 104.2 Trenches, Tunneling, and Driving.** Trenches shall comply with Section 317.1. Tunneling and driving shall comply with Section 317.2.

**F 104.3 Excavations and Open Trenches.** Excavations required to be made for the installation of piping or tubing shall be in accordance with Section 317.3. 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 317.4.

**F 104.4 Protection of Piping, Materials, and Structures.** Piping and tubing passing under or through walls shall be protected from breakage in accordance with Section 316.1. Piping and tubing shall be installed in accordance with Section 316.2 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.

**F 104.5 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 316.7 through Section 316.7.2.

**F 104.6 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 316.6.

**E 509.2 F 104.7 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.

**F 105.0 Specific System Components Design.**

**F 105.1 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 1218.1. 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.

**F 105.2 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 (27.8°C) above the maximum system operating temperature. For DX systems, the heat transfer medium shall be a refrigerant listed in ASHRAE 34 or this code.

**F 105.3 On Site Storage.** Exterior piping shall be fitted with end caps and protected from freezing, UV radiation, corrosion, and degradation. For DX systems, copper piping and fittings shall be stored to prevent physical damage, contamination, and each pipe or tubing shall be pressurized with an inert gas and sealed with a cap.
F 105.4 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.

SUBSTANTIATION:
Piping installed within or under a footing or foundation wall must be structurally protected from any transferred loading from the footing or foundation wall. This protection may be provided by a relieving arch or a pipe sleeve. When a sleeve is used, it must be sized larger than the penetrating pipe. This space will allow for any differential movement of the pipe. By providing structural protection to the piping system, the piping will not be subjected to undue stresses that could cause it to rupture and leak. A section was added to minimize the possibility of pipe damage caused by nails, screws or other fasteners. Because nails and screws sometimes miss the stud, rafter, joist or sole or top plates, the shield must protect the pipe through the full width of the member on each side and must extend not less than 2 inches above or below the sole or top wall plates. A trench must be wide enough to allow for proper alignment of the piping system. Piping is best supported when it rests directly on the bottom of a solid, continuous trench for its entire length. Piping must not be supported intermittently by hard surfaces, such as rock or concrete as this creates “point loads” on the pipe wall. Bedding provides a continuous “smooth” cradled support to ensure that the pipe is not exposed to concentrated “point” loads which could ultimately cause pipe failure. Proper backfilling technique is important to ensure that the pipe remains aligned in its bedded position, especially where there will be loads from additional backfill. Piping in trenches under a slab-on-ground building need not be buried any more than what is necessary to provide for a full thickness of the concrete slab above. There are many variables to consider during the design and installation of hangers and supports. Consideration must be given to the type and size of the pipe material; the weight of the pipe, fittings and contents; the structural element available for attachment; earthquake motions; vibration-sensitive applications and thermal expansion and contraction. Other load conditions to consider include the weight of valves and appurtenances; insulating materials; and hanger and support components. When the hanger or strapping material is not compatible with the piping material it supports, corrosion caused by galvanic action can occur. This happens when dissimilar metals are in contact with one another and sufficient moisture is present to carry an electrical current. Such corrosion can deteriorate the hanger, anchor or piping to the point of failure. Where metallic pipe is installed, the hangers or supports must be of similar material to prevent any corrosive galvanic action. Ultimately, a support is only as strong as its means of attachment and the member to which it is attached. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 166

UMC 2021  Section: F 106.0 - F 106.2

SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Add new text

**F 106.0 Ground-Heat Exchanger Testing.**

**F 106.1 Testing.** Pressure-testing of the ground-heat exchanger shall be performed in accordance with the testing method in Section F 103.4.

**F 106.2 DX System Testing.** For DX systems, each loop shall be tested with an inert gas at not less than 315 psi (2172 kPa) for not less than 15 minutes without pressure drop. The pressure reading after grouting of the boreholes shall be maintained in the ground-heat exchanger for not less than 2 hours.

SUBSTANTIATION:
Testing is necessary to make sure that the system is free from leaks or other defects. Testing is also required, to the extent specified in the technical chapters of the code. For DX systems, after each loop is assembled, a pressure test using air or an inert gas is required to determine whether the system leaks. Refrigerant cannot be used for testing because the purpose of testing is to find and repair any leaks before the system is charged with refrigerant, thereby preventing exposure of anyone to the refrigerant. Also, testing with refrigerant introduces the additional and unnecessary risk of environmental damage from release of refrigerant to the atmosphere. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  **AFFIRMATIVE:** 25  **NOT RETURNED:** 1  **HOWARD**
**F 107.0 Heat Pump and Distribution System Design.**

**F 107.1 General.** Ground coupled and water source heat pumps shall be certified in accordance with AHRI/ASHRAE/ISO 13256-1 for water-to-air heat pumps and AHRI/ASHRAE/ISO 13256-2 for water-to water heat pumps. DX heat pumps shall be certified in accordance with ASHRAE 194. All heat pump equipment used in DX systems shall comply with AHRI 870. Heat pumps shall be fitted with a means to indicate that the compressor is locked out.

**F 107.2 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 313.0 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.

**F 107.3 Circulating Pumps.** The circulating pump shall be sized for the operating conditions and the heat transfer fluid properties.

**F 107.4 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.

**TABLE 1701.2**

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHRI 870-2016</td>
<td>Performance Rating of Direct Geoxchange Heat Pumps</td>
<td>Heat Pumps</td>
</tr>
<tr>
<td>ASHRAE 194-2012</td>
<td>Method of Test for Direct-Expansion Ground-Source Heat Pumps</td>
<td>Ground-Source Heat Pumps</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

**SUBSTANTIATION:**
Proper sizing of the circulating pump will be within the heat pump manufacturer’s required flow rate range for the specified unit. Isolation valves are necessary in such systems so that major components can be isolated from the system to accommodate servicing as well as protecting the components when required pressure testing. Valves must be located on the supply and return piping so that the component or group of components may be separated from the rest of the system when servicing is required. Valves are also used to take system components out of service temporarily. Isolation valves should be installed to allow the isolation of any device or component that will require servicing, repair or replacement at regular intervals. Flow balancing is a set of techniques to ensure that the intended amount of water reaches each terminal unit. This is done typically by
means of calibrated flow control valves placed throughout the building. Balancing also enables the detection and correction of problems (i.e., air in
system, deficient balancing valves, etc.). If the system is not balanced properly water will flow to the path of least resistance causing temperature
variation and increased operating costs. Flow sensing devices must be installed with any direct fired heat source which requires forced circulation to
avoid overheating such as those with coil or fin tube type exchangers that will shut down the supply. Furthermore, this will correlate with the action
taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
SUBMITTER: Cary Smith
Sound Geothermal Corporation

RECOMMENDATION:
Revise text

F 108.0 System Start-Up.

F 108.1 General. The following requirements shall be verified prior to system start-up.
(1) Piping shall be cleaned, flushed, and purged.
(2) DX systems shall be pressurized using nitrogen for not less than 1 hour. There shall be no allowable variance to the test pressure after being corrected for ambient temperature changes during the test. The test pressure shall not exceed 150 psig (1034 kPa) when pressure testing the compressor unit and indoor system components.
(3) The ground heat exchanger and building piping shall be cleaned, flushed, and, where required, shall be filled with the heat transfer fluid medium. The ground loop system shall be tested at the design flow rate(s) and differential pressure(s) recorded. Where the actual pressure change at design flow is more than +/- 10 percent of the design flow pressure drop, the cause shall be identified and corrective action taken.
(4) A method for the removal of air and a method for adding heat transfer fluid (where necessary) shall be provided.
(5) The heat pumps shall be operational and adjustments shall be made in accordance with the manufacturer's installation instructions.
(6) All necessary additional flow tests of the ground heat exchanger shall be completed prior to heat pump start-up.
(7) Ground heat exchanger and building piping, valves, and operating controls, shall be set, adjusted, and operating as required.
(8) 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.
(9) DX systems shall have permanent type labels installed and affixed on the compressor unit with the refrigerant type and quantity.
(10) Supply and return lines, as well as associated isolation valves from individual boreholes or water wells, shall be identified and tagged.
(11) For DX systems, refrigerant liquid and vapor lines from the loop system shall be identified and tagged.
(12) Supply and return lines on submerged systems shall be identified in an approved manner, at the point of entry to a surface water resource.

F 108.2 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.

E 508.10 F 108.3 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.

E 507.0 F 109.0 Valves.

E 507.4 F 109.1 Where Required. Shutoff valves shall be installed in ground source-loop piping systems in the locations indicated in Section E 507.2 F 109.2 through Section E 507.8 F 109.8.

E 507.2 F 109.2 Heat Exchangers. Shutoff valves shall be installed on the supply and return side of a heat exchanger, except 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.

**E 507.3** **F 109.3** Central Systems. Shutoff valves shall be installed on the building supply and return of a central utility system.

**E 507.4** **F 109.4** Pressure Vessels. Shutoff valves shall be installed on the connection to a pressure vessel.

**E 507.5** **F 109.5** Pressure-Reducing Valves. Shutoff valves shall be installed on both sides of a pressure-reducing valve.

**E 507.6** **F 109.6** Equipment and Appliances. Shutoff valves shall be installed on connections to mechanical equipment and appliances. This requirement does not apply to components of a ground source loop system such as pumps, air separators, metering devices, and similar equipment.

**E 507.7** **F 109.7** Expansion Tanks. Shutoff valves shall be installed at connections to nondiaphragm-type expansion tanks.

**E 507.8** **F 109.8** 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.

**E 505.0** Geothermal Systems.

**E 505.1** Applicability. Geothermal systems that use the earth or body of water as a heat source or sink for heating or cooling shall be in accordance with Section E 505.1.1 through Section E 509.2.

**E 505.1.1** Design, Installation, and Testing. Geothermal systems shall be designed by a registered design professional. The geothermal system design, installation, and testing shall be in accordance with CSA C448.

**E 505.1.2** Heat Pump Approval. Water source heat pumps used in conjunction with geothermal heat exchangers shall be listed and labeled for use in such systems and shall be designed for the minimum and maximum design water temperature.

**E 505.2** Ground Source Heat Pump-Loop Systems. Ground source heat pump-ground loop piping and tubing material for water-based systems shall comply with the standards cited in this appendix.

**E 505.3** Material Rating. Piping shall be rated for the operating temperature and pressure of the ground source heat pump-loop system. Fittings shall be rated for the temperature and pressure applications and recommended by the manufacturer for installation with the piping material installed. Where used underground, materials shall be approved for burial.

**E 506.0** Joints and Connections.

**E 506.1** Approval. Joints and connections shall be of an approved type. Joints and connections shall be tight for the pressure of the ground source-loop system. Joints and fittings used underground shall be approved for buried applications.

**E 506.2** Joints Between Various Materials. Joints between various piping materials shall be made with approved transition fittings.

**E 506.3** Preparation of Pipe Ends. Pipe shall be cut square, reamed, and free of burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut. CPVC, PE, and PVC pipe shall be chamfered.

**E 506.4** Joint Preparation and Installation. Where required by Section E 506.5 through Section E 506.12.2, the preparation and installation of mechanical and thermoplastic welded joints shall be in accordance with Section E 506.4 and Section E 506.5.

**E 506.5** Mechanical Joints. Mechanical joints shall be installed in accordance with the manufacturer’s installation instructions.

**E 506.6** Thermoplastic Welded Joints. Joint surfaces for thermoplastic welded joints shall be cleaned by an approved procedure. Joints shall be welded in accordance with the manufacturer’s installation instructions.

**E 506.7** CPVC Plastic Pipe. Joints between CPVC plastic piping and fittings shall comply with Section E 506.7.1 and Section E 506.7.2.

**E 506.7.1** Threaded Joints. Threads shall comply with ASME B1.20.1. Schedule 80 or heavier plastic pipe shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

**E 506.7.2** Solvent Cement. Solvent cement joints for CPVC pipe and fittings shall be clean from dirt and moisture. Solvent cement 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 or red in color shall be permitted for pipe and fittings manufactured in accordance with ASTM D2846, 1/2 of an inch (15 mm) through 2 inches (50 mm) in diameter.

**E 506.8** Cross-Linked Polyethylene (PEX) Plastic Tubing. Compression or plastic to metal transition joints between cross-linked polyethylene plastic tubing and fittings shall comply with Section E 506.8.1 and Section E 506.8.2. Mechanical joints shall
comply with Section E 506.5.

E 506.8.1 Compression-Type Fittings. Where compression type fittings include inserts and ferrules or o-rings, the fittings shall be installed with the inserts and ferrules or o-rings.

E 506.8.2 Plastic-to-Metal Connections. Soldering on the metal portion of the system shall be performed not less than 18 inches (457 mm) from a plastic-to-metal adapter in the same water line.

E 506.9 Polyethylene Plastic Pipe and Tubing. Joints between polyethylene plastic piping shall comply with Section E 506.9.1 through Section E 506.9.3.

E 506.9.1 Heat-Fusion Joints. Joints shall be of the socket-fusion, saddle-fusion, or butt-fusion type and joined in accordance with ASTM D2657. Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

E 506.9.2 Electrofusion Joints. Joints shall be of the electrofusion type. Joint surfaces shall be clean and free of moisture, and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

E 506.9.3 Stab-Type Insert Fittings. Joint surfaces shall be clean and free of moisture. Pipe ends shall be chamfered and inserted into the fittings to full depth. Fittings shall be manufactured in accordance with ASTM F1924.

E 506.10 Polypropylene (PP) Plastic. Joints between PP plastic pipe and fittings shall comply with Section E 506.10.1 and Section E 506.10.2.

E 506.10.1 Heat-Fusion Joints. Heat-fusion joints for polypropylene (PP) pipe and tubing joints shall be installed with socket type heat fused polypropylene fittings, electrofusion polypropylene fittings, or by butt fusion. 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.

E 506.10.2 Mechanical and Compression Sleeve Joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions.

E 506.11 Raised Temperature Polyethylene (PE-RT) Plastic Tubing. Joints between raised temperature polyethylene tubing and fittings shall comply with Section E 506.11.1 and Section E 506.11.2. Mechanical joints shall comply with Section E 506.5.

E 506.11.1 Compression-Type Fittings. Where compression type fittings include inserts and ferrules or o-rings, the fittings shall be installed without omitting the inserts and ferrules or o-rings.

E 506.11.2 PE-RT-to-Metal Connections. Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-RT pipe.

E 506.12 PVC Plastic Pipe. Joints between PVC plastic pipe and fittings shall comply with Section E 506.12.1 and Section E 506.12.2.

E 506.12.1 Solvent Cement Joints. Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Purple primer in accordance with ASTM F656 shall be applied until the surface of the pipe and fitting is softened. Solvent cement in accordance with ASTM D2564 shall be applied to joint surfaces.

E 506.12.2 Threaded Joints. Threads shall comply with ASME B1.20.1. Schedule 80 or heavier plastic pipe shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

E 508.0 Installation.

E 508.1 General. Piping, valves, fittings, and connections shall be installed in accordance with the manufacturer’s installation instructions.

E 508.2 Protection of Potable Water. Where ground source heat pump ground loop systems have a connection to a potable water supply, the potable water system shall be protected.

E 508.3 Pipe Penetrations. Openings for pipe penetrations in walls, floors, and ceilings shall be larger than the penetrating pipe. Openings through concrete or masonry building elements shall be sleeved. The annular space surrounding pipe penetrations shall be protected in accordance with the building code.

E 508.4 Clearance from Combustibles. A pipe in a ground source heat pump piping system, having an exterior surface temperature exceeding 250°F (121°C), shall have a clearance of not less than 1 inch (25.4 mm) from combustible materials.

E 509.0 Testing.

E 509.1 Ground Source Heat Pump Loop System Testing. Before connection header trenches are backfilled, the assembled loop system shall be pressure tested with water at 100 psi (689 kPa) for 15 minutes with no observed leaks. Flow and pressure loss testing shall be performed, and the actual flow rates and pressure drops shall be compared to the calculated design values. Where actual flow rate or pressure drop values differ from calculated design values by more than 10 percent, the cause shall be identified and corrective action taken.
SUBSTANTIATION:
A static system check is performed before the system is turned on to identify obvious problems that must be resolved before proper operation can be expected. A dynamic system check is performed after the system has been started and consists of measuring various system performance parameters to ensure that the system is performing as promised. Many checklists are commercially available for each type of system. During construction, excavation, and pipe assembly create the greatest opportunity for dirt and construction residue, or other contaminants, while avoiding contact with the pump impellers and any other system interior piping components. Before starting the completed system, the piping must be flushed, purged and pressurized. Sections E 505.0 through Section E 509.0 are being deleted as they are already addressed with the appendices. Furthermore, this will correlate with the action taken by the USEHC Technical Committee.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Part II Open-Loop Systems

F 201.0 General.

F 201.1 Applicability. Part II of this appendix 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 appendix 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 F 103.7 and Chapter 12.

F 201.1.1 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.

F 201.1.2 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.

F 201.2 Construction Documents. The construction documents for the building system portion of the geothermal energy system shall be submitted to the Authority Having Jurisdiction.

F 201.3 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.

F 201.4 Subsurface investigation. A subsurface investigation shall be performed in accordance with Section F 201.4.1 as determined by the registered design professional conducting the site survey.

F 201.4.1 Subsurface Conditions. The water well logs and other geological records shall be used to anticipate the subsurface conditions of the aquifer and its potential supply of fresh water, multiple aquifers, saltwater intrusions, contaminated soils and groundwater, hazardous gases, and any interference with neighboring water wells and ground source heat exchangers.

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

SUBSTANTIATION:

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 170
UMC 2021  Section: F 201.5

SUBMITTER: Roshan Revankar
IGSHPA - International Ground Source Heat Pump Association

RECOMMENDATION:
Add new text

**F 201.5 Setbacks.** Open loop ground-heat exchangers shall maintain the following setbacks:
(a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Twenty feet (6096 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c) Three feet (914 mm) horizontally from buried utilities such as electrical, gas, or water.
(d) Fifty feet (15 240 mm) from a water well.
(e) Fifty feet (15 240 mm) from a septic tank and 100 feet (30 480 mm) from a subsurface sewage leaching field.
(f) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.

SUBSTANTIATION:
Setback guidance is provided for open-loop ground-heat exchanger systems. Setbacks are intended to represent geologic averages to create effective retention time for contaminants that may be present in groundwater. Setbacks are a factor of porosity (the ratio of the void volume of a rock to the total volume of the rock, usually expressed as a percentage) and permeability (the measure of the relative ease with which a porous media can transmit a liquid under a potential gradient) of the subsurface and how groundwater will flow through a property. The proposed setbacks will help ensure safe operation.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC
Amend proposal as follows:

**F 201.5 Setbacks.** Open loop ground-heat exchangers shall maintain the following **minimum** setbacks or at distances specified by the Authority Having Jurisdiction:
(a) Ten feet (3048 mm) horizontally from a pressure-tested sewer lateral into a building.
(b) Twenty feet (6096 mm) horizontally from a non-pressure tested sewer lateral into a building.
(c) Three feet (914 mm) horizontally from buried utilities such as electrical, gas, or water.
(d) Fifty feet (15 240 mm) from a water well.
(e) Fifty feet (15 240 mm) from a septic tank and 100 feet (30 480 mm) from a subsurface sewage leaching field.
(f) One hundred feet (30 480 mm) from a spring; or at distances specified by the Authority Having Jurisdiction.

COMMITTEE STATEMENT:
The proposed text is being modified to clarify that the AHJ shall make the final decision on setback requirements. Furthermore, the modification clarifies that these are minimum setback requirements.

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD

EXPLANATION OF AFFIRMATIVE:

P. TRAFTON: I am in agreement with the committee
SUBMITTER: Roshan Revankar
IGSHPA - International Ground Source Heat Pump Association

RECOMMENDATION:
Add new text

**F 202.0 Open Ground Water Systems.**

**F 202.1 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.

**F 202.2 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.

**F 202.3 Design Considerations.** A groundwater heat pump system shall be designed by a registered design professional. Due design consideration shall be given to the following:

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

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

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 172

UMC 2021 Section: F 202.4 - F 202.6, and 205.0

SUBMITTER: Roshan Revankar
IGSHA - International Ground Source Heat Pump Association

RECOMMENDATION:
Revise text

F 202.4 Water Wells and Injection Wells. Water wells and injection wells for groundwater heat pump systems shall be installed and tested by a registered designed professional who 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.

F 202.5 Testing and Sampling. Pumping tests and water sampling shall be done as required by the registered design professional.

F 202.6 Disinfection. Water wells shall be disinfected upon completion in accordance with requirements of the Authority Having Jurisdiction and NGWA-01.

205.0 – C –

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.

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<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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<tbody>
<tr>
<td>NGWA-01-2014</td>
<td>Water Well Construction Standard</td>
<td>Water Wells</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:
Water well and injection well tests must be performed for both water flow and water quality. In order to gain information about the producing aquifer, drawdown at other points in the area of the well, future drawdown and influences on other wells, a multi-well test shall be performed. In this test, the production well is pumped at a controlled rate, and at least one nearby well is monitored for water level. Test periods shall be 24 hours or longer. The purpose of water quality testing is to determine the chemical nature of the water and its impact upon system materials selection and maintenance requirements. Water quality testing is a critical part of the well testing phase to determine whether water chemistry issues exist. The definition for “water well” distinguishes its function as an open-loop “ground-coupling” as opposed to a closed-loop ground-coupling with a geothermal energy system.

COMMITTEE ACTION: ACCEPT AS AMENDED BY THE TC

Amend proposal as follows:

F 202.4 Water Wells and Injection Wells. Water wells and injection wells for groundwater heat pump systems shall be installed and tested by a registered designed professional who 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.

F 202.5 Testing and Sampling. Pumping tests and water sampling shall be done as required by the registered design professional.

F 202.6 Disinfection. Water wells shall be disinfected upon completion in accordance with requirements of the Authority Having Jurisdiction and NGWA-01.
**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.

**F 101.2 Definitions.**

**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.

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</table>

(portions of table not shown remain unchanged)

**COMMITTEE STATEMENT:**
The proposed modification relocates the definition of "Water Well" from Chapter 2 to Appendix F as it is only addressed in Appendix F.

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**

**AFFIRMATIVE:** 25 **NOT RETURNED:** 1

**HOWARD**

**EXPLANATION OF AFFIRMATIVE:**

P. TRAFTON: I am in agreement with the committee
Item #: 173
UMC 2021  Section: F 203.0 - F 203.2.8

SUBMITTER: Roshan Revankar
IGSHPA - International Ground Source Heat Pump Association

RECOMMENDATION:
Add new text

F 203.0 Horizontal Piping from Extraction Wells and to Injection Wells - Materials and Methods.
F 203.1 Piping material. Piping materials and joining methods for horizontal piping from extraction wells and to injection wells shall in accordance with Section F 103.5, Section F 103.6, Section F 103.7, Section F 103.8 and Section F 103.9.
F 203.1.1 Dissimilar Materials. Transition fittings between dissimilar materials shall be inside or accessible.
F 203.1.2 Protection of Piping. Pipes passing through walls shall be sleeved and sealed in accordance with Section 316.0.
F 203.2 Trenches, Excavation, and Backfilled. Excavation for horizontal piping shall comply with Section F 203.2.1 through Section F 203.2.8, Section F 104.1 through Section F 104.4, 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.
F 203.2.1 Trenches. Trenches for underground piping or tubing shall be excavated in accordance with the setbacks requirements in Section F 201.5.
F 203.2.2 Buried Systems. Buried open-loop system piping, shall be installed not less than 3.3 feet (1006 mm) below the finished grade.
F 203.2.3 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.
F 203.2.4 Separation. The horizontal piping shall be separated from fluid-based on-site services systems to prevent excessive short-circuiting heat transfer between such systems.
F 203.2.5 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.
F 203.2.6 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.
F 203.2.7 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 R2 minimum closed cell insulation.
F 203.2.8 Tracer Markings. Means shall be provided for underground detection or utility location of the buried pipe system. This shall include, but is not limited to metallic detectable tape, with a thickness of not less than 11/64 of an inch (4.4 mm) and length of 6 inches (152 mm).

This warning marking shall be permanent, conspicuous and resistant to the environmental conditions and shall be placed within 1 foot to 2 feet (305 mm to 610 mm) on top of the horizontal piping of the heat exchanger installation.

SUBSTANTIATION:
Piping and joining methods for horizontal pipe are defined by reference in this section of the Appendix. Trenching topics, including excavation, piping depth, backfilling, soil compaction, piping configuration and separation of system piping from nearby gas, electric, water and waste utilities are addressed, as is insulation from other heating/cooling sources that would reduce system efficiency. This subsection also addresses permanent traceability of underground piping locations.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 174

UMC 2021  Section: F 204.0 - F 204.7

SUBMITTER: Roshan Revankar
IGSHPA - International Ground Source Heat Pump Association

RECOMMENDATION:
Add new text

F 204.0 Testing and Verification.
F 204.1 Pumping Test. Water supply wells and injection wells shall undergo a stop and start pumping test to demonstrate the sand-free yield.
F 204.2 Retesting. Where sediment is present, the problem shall be corrected and the test shall be repeated until acceptable results are obtained.
F 204.3 Variable Rate Pump Test. The operating conditions of the water supply wells and injection wells shall be evaluated and verify with a variable rate pumping.
F 204.4 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 duration as specified by the registered designed professional.
F 204.5 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 designed professional.
F 204.6 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 designed professional. The results of the drilling and pumping tests shall be provided to the owner or the owner’s representative and provided in accordance with requirements of the Authority Having Jurisdiction.
F 204.7 Re-Injected Water. The water quality of re-injected water into the earth shall comply with the requirements of the Authority Having Jurisdiction.

SUBSTANTIATION:
Variable and constant rate pump testing procedures are necessary to ensure that the system is free from leaks or other defects, and to verify that the water supply volume and chemical content are within specified limits. Monitoring of nearby wells during the testing phase contributes to understanding of the aquifer characteristics, leading to reliable system design and operation. In addition this section specifies that all water re-injection must comply with AHJ requirements.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 175
UMC 2021  Section: F 205.0 - F 205.5

SUBMITTER: Roshan Revankar
IGSHPA - International Ground Source Heat Pump Association

RECOMMENDATION:
Revise text

F 205.0 System Start-Up and Delivery.

F 205.1 Documentation. The ground source heat pump system as-built installation drawings and instructions shall be provided to the building owner or designated agent.

F 205.2 Maintenance. The periodic maintenance required, in accordance with the design requirements, shall be provided and be made available to the owner or designated agent.

F 205.3 Records. The ground source heat pump system construction documents shall be provided to the owner.

F 205.4 System Start-Up. System startup shall be in accordance with CSA C448.1, CSA C448.2, and Section F 206.0.

F 205.5 Contaminants. Particulate contaminants shall be removed from indoor piping system prior to initial start-up.

### TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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<th>DOCUMENT NUMBER</th>
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<tr>
<td>CSA C448.2-2016</td>
<td>Design and Installation of Ground Source Heat Pump Systems for Residential and Other Small Buildings</td>
<td>Ground-Source Heat Pumps</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:
An integral part of system commissioning includes the drafting of as-built drawings/schematics of the project, and the delivery of those documents to the owner/operator. An essential part of this documentation includes OEM manuals for all system components, startup records, and required maintenance tasks and schedule.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 176

UMC 2021  Section: F 206.0 - F 206.1

SUBMITTER: Roshan Revankar
IGSHPA - International Ground Source Heat Pump Association

RECOMMENDATION:
Add new text

F 206.0 Decommissioning and Abandonment.
F 206.1 General. Prior to the abandonment or decommissioning of an open-loop system, the owner shall obtain the necessary permits from the Authority Having Jurisdiction.

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

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 177

UMC 2021  Section: Appendix F: F 101.4 - F 103.0

SUBMITTER: IAPMO Staff - Update Extracts
NFPA 54 Extract Update

RECOMMENDATION:
Revise text

F 101.0 General.
F 101.4 Example 2: Single Fan-Assisted Appliance. An installer has an 80 000 Btu/h (23.4 kW) input fan-assisted appliance that shall must be installed using 10 feet (3048 mm) of lateral connector attached to a 30 foot (9144 mm) high Type B vent. Two 90-degree (1.57 rad) elbows are needed for the installation. Is Can a single-wall metal vent connector permitted to be used for this application? (See Figure F 101.4)

Solution:
Table 803.1.2(2) refers to the use of single-wall metal vent connectors with Type B vent. In the first column find the row associated with a 30 foot (9144 mm) height and a 10 foot (3048 mm) lateral. Read across this row, looking at the FAN Min and FAN Max columns, to find that a 3 inch (76 mm) diameter single-wall metal vent connector is not recommended. Moving to the next larger size single-wall connector [4 inch (102 mm)] we find that a 4 inch (102 mm) diameter single-wall metal connector has a recommended minimum vent capacity of 91 000 Btu/hr (26.7 kW) and a recommended maximum vent capacity of 144 000 Btu/hr (42 kW). The 80 000 Btu/hr (23.4 kW) fan-assisted appliance is outside this range, so the conclusion is that a single-wall metal vent connector shall not cannot be used to vent the this appliance using a 10 foot (3048 mm) of lateral for the connector. However, if the 80 000 Btu/hr (23.4 kW) input appliance is could be moved within 5 feet (1524 mm) of the vertical vent, a 4 inch (102 mm) single-wall metal connector shall could be used to vent the appliance. Table 803.1.2(2) shows the acceptable range of vent capacities for a 4 inch (102 mm) vent with 5 feet (1524 mm) of lateral to be between 72 000 Btu/hr (21.1 kW) and 157 000 Btu/hr (46 kW).

Where If the appliance cannot be moved closer to the vertical vent, then a Type B vent shall could be used as the connector material. In this case, Table 803.1.2(1) shows that, for a 30 foot (9144 mm) high vent with 10 feet (3048 mm) of lateral, the acceptable range of vent capacities for a 4 inch (102 mm) diameter vent attached to a fan-assisted appliance is between 37 000 Btu/hr (10.8 kW) and 150 000 Btu/hr (44 kW).

F 101.5 Example 3: Interpolating Between Table Values. An installer has an 80 000 Btu/hr (23.4 kW) input appliance with a 4 inch (102 mm) diameter draft hood outlet that needs to be vented into a 12 foot (3658 mm) high Type B vent. The vent connector has a 5 foot (1524 mm) lateral length and is also Type B. Can Is this appliance permitted to be vented using a 4 inch (102 mm) diameter vent?

Solution:
Table 803.1.2(1) is used in the case of an all Type B Vent system. However, since there is no entry in Table 803.1.2(1) does not have an entry for a height of 12 feet (3658 mm), and interpolation shall must be used. Read down the 4 inch (102 mm) diameter NAT Max column to the row associated with a 10 foot (3048 mm) height and 5 foot (1524 mm) lateral to find the capacity value of 77 000 Btu/hr (22.6 kW). Read further down to the 15 foot (4572 mm) height, 5 foot (1524 mm) lateral row to find the capacity value of 87 000 Btu/hr (25.5 kW). The difference between the 15 foot (4572 mm) height capacity value and the 10 foot (3048 mm) height capacity value is 10 000 Btu/hr (3 kW). The capacity for a vent system with a 12 foot (3658 mm) height is equal to the capacity for a 10 foot (3048 mm) height plus two-fifths of the difference between the 10 foot (3048 mm) and 15 foot (4572 mm) height values, or 77 000 Btu/hr (22.6 kW) + 2/5 x 10 000 Btu/hr (3 kW) = 81 000 Btu/hr (23.7 kW). Therefore, a 4 inch (102 mm) diameter vent shall can be used in the installation.

F 102.0 Examples Using Common Venting Tables.
F 102.1 Example 4: Common Venting Two Draft Hood-Equipped Appliances. A 35 000 Btu/hr (10.3 kW) water heater is to be common vented with a 150 000 Btu/hr (44 kW) furnace, using a common vent with a total height of 30 feet (9144 mm). The connector rise is 2 feet (610 mm) for the water heater with a horizontal length of 4 feet (1219 mm). The connector rise for the furnace is 3 feet (914 mm) with a horizontal length of 8 feet (2438 mm). Assume single-wall metal connectors will be used with Type B vent. What size connectors and combined vent should be used in this installation? (See Figure F 102.1)
Solution:

Table 803.2(2) shall should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 803.2(2), find the row associated with a 30 foot (9144 mm) vent height. For a 2 foot (610 mm) rise on the vent connector for the water heater, read the shaded columns for draft hood-equipped appliances to find that a 3 inch (76 mm) diameter vent connector has a capacity of 37 000 Btu/h (10.8 kW). Therefore, a 3 inch (76 mm) single-wall metal vent connector shall can be used with the water heater. For a draft hood-equipped furnace with a 3 foot (914 mm) rise, read across the appropriate row to find that a 5 inch (127 mm) diameter vent connector has a maximum capacity of 120 000 Btu/h (35 kW) (which is too small for the furnace), and a 6 inch (152 mm) diameter vent connector has a maximum vent capacity of 172 000 Btu/h (50 kW). Therefore, a 6 inch (152 mm) diameter vent connector shall should be used with the 150 000 Btu/h (44 kW) furnace. Since Because both vent connector horizontal lengths are less than the maximum lengths listed in Section 803.2.1, the table values shall can be used without adjustments.

In the common vent capacity portion of Table 803.2(2), find the row associated with a 30 foot (9144 mm) vent height and read over to the NAT + NAT portion of the 6 inch (152 mm) diameter column to find a maximum combined capacity of 257 000 Btu/h (75 kW). Since the two appliances total only 185 000 Btu/h (54 kW), a 6 inch (152 mm) common vent shall can be used.

F 102.2 Example 5(a): Common Venting a Draft Hood-Equipped Water Heater with a Fan-Assisted Furnace into a Type B Vent. In this case, a 35 000 Btu/h (10.3 kW) input draft hood-equipped water heater with a 4 inch (102 mm) diameter draft hood outlet, 2 feet (610 mm) of connector rise, and 4 feet (1219 mm) of horizontal length is to be common vented with a 100 000 Btu/h (29 kW) fan-assisted furnace with a 4 inch (102 mm) diameter flue collar, 3 feet (914 mm) of connector rise, and 6 feet (1829 mm) of horizontal length. The common vent consists of a 30 foot (9144 mm) height of Type B vent. What are the recommended vent connector diameters, and is this an acceptable installation?

Solution:

Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 feet (1219 mm) is less than the maximum value listed in Table 803.2(2), the venting table values shall can be used without adjustments. Using the Vent Connector Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and read across the 2 feet (610 mm) Connector Rise (R) row to the first Btu/h rating in the NAT Max column that is equal to or exceeding greater than the water heater input rating. The table shows that a 3 inch (76 mm) vent connector has a maximum input rating of 37 000 Btu/h (10.8 kW). Although this rating is exceeding greater than the water heater input rating, a 3 inch (76 mm) vent connector is prohibited by Section 803.2.18. A 4 inch (102 mm) vent connector has a maximum input rating of 67 000 Btu/h (19.6 kW) and is equal to the draft hood outlet diameter. A 4 inch (102 mm) vent connector is selected. Since the water heater is equipped with a draft hood, there are no minimum input rating restrictions.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and across the 3 feet (914 mm) Connector Rise (R) row. Since Because the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/h rating exceeding greater than the furnace input rating. The 4 inch (102 mm) vent connector has a maximum input rating of 119 000 Btu/h (34.9 kW) and is less than the maximum value listed in Section 803.2.1, the venting table values shall can be used without adjustment. Where If the furnace had an input rating of 80 000 Btu/h (23.4 kW), then a Type B vent connector shall would be needed in order to meet the minimum capacity limit.

Common Vent Diameter. The total input to the common vent is 135 000 Btu/h (40 kW). Using the Common Vent Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and across this row to find the smallest vent diameter in the FAN + NAT column that has a Btu/h rating equal to or exceeding greater than 135 000 Btu/h (40 kW). The 4 inch (102 mm) common vent has a capacity of 132 000 Btu/h (39 kW) and the 5 inch (127 mm) common vent has a capacity of 202 000 Btu/h (59 kW). Therefore, the 5 inch (127 mm) common vent shall should be used in this example.

Summary: In this example, the installer shall can use a 4 inch (102 mm) diameter, single-wall metal vent connector for the water heater and a 4 inch (102 mm) diameter, single-wall metal vent connector for the furnace. The common vent shall should be a 5 inch (127 mm) diameter Type B vent.

F 102.3 Example 5(b): Common Venting into an Interior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Example 5(a) are to be common-vented into a clay-tile claytile-lined masonry chimney with a 30 foot (9144 mm) height. The chimney is not exposed to the outdoors below the roof line. The internal dimensions of the clay tile liner are nominally 8 inches (203 mm) by 12 inches (305 mm). Assuming the same vent connector heights, laterals, and materials found in Example 5(a), what are the recommended vent connector diameters, and is this an acceptable installation?

Solution:

Table 803.2(4) is used to size common venting installations involving single-wall connectors into masonry chimneys.

Water Heater Vent Connector Diameter. Using Table 803.2(4), Vent Connector Capacity, read down the Total Vent Height (H) column to 30 feet (9144 mm), and read across the 2 feet (610 mm) Connector Rise/R row to the first Btu/h rating in the NAT Max column that is equal to or exceeding greater than the water heater input rating. The table shows that a 3 inch (76 mm) vent connector has
A maximum input of only 31,000 Btu/h (9 kW), while a 4 inch (102 mm) vent connector has a maximum input of 57,000 Btu/h (16.7 kW). A 4 inch (102 mm) vent connector must therefore be used.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 803.2(4), read down the total Total Vent Height \(H\) column to 30 feet (914 mm) and across the 3 feet (914 mm) Connector Rise \(R\) row. Because the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/h rating exceeding greater than the furnace input rating. The 4 inch (102 mm) vent connector has a maximum input rating of 127,000 Btu/h (37 kW) and an a minimum input rating of not less than 95,000 Btu/h (27.8 kW). The 100,000 Btu/h (29 kW) furnace in this example falls within this range, so a 4 inch (102 mm) connector shall be permitted is adequate.

Masonry Chimney. From Table F 102.3, the Equivalent Area for a Nanminal Liner size of 8 inches (203 mm) by 12 inches (305 mm) is 63.6 of a square inches (0.041 m\(^2\)). Using Table 803.2(4), Common Vent Capacity, read down the FAN + NAT column under the Minimum Internal Area of Chimney value of 63 to the row for 30 foot (9144 mm) height to find a capacity value of 739,000 Btu/h (217 kW). The combined input rating of the furnace and water heater, 135,000 Btu/h (40 kW), is less than the table value so this is an acceptable installation.

Section 803.2.17 requires the common vent area to not exceed be no greater than seven times the smallest listed appliance categorized vent area, flue collar area, or draft hood outlet area. Both appliances in this installation have 4 inch (102 mm) diameter outlets. From Table F 102.3, the equivalent area for an inside diameter of 4 inches (102 mm) is 12.2 of a square inches (0.008 m\(^2\)). Seven times 12.2 equals 85.4, which is exceeding greater than 63.6, so this configuration is acceptable.

**F 103.0 Example of Combination Indoor and Outdoor Combustion Air Opening Design.** Determine the required combination of indoor and outdoor combustion air opening sizes for the following appliance installation example.

Example Installation: A fan-assisted furnace and a draft hood-equipped water heater with the following inputs are located in a 15 foot by 30 foot (4572 mm by 9144 mm) basement with an 8 foot (2438 mm) ceiling. No additional indoor spaces can be used to help meet the appliance combustion air needs.

**Solution:**

1. **Determine the total available room volume.**
   
   Appliance room volume.
   
   
   15 feet by 30 feet (4572 mm by 9144 mm) with an 8 foot (2438 mm) ceiling = 3600 cubic feet (101.94 m\(^3\))

2. **Determine the total required volume.**
   
   The Standard Method to determine combustion air shall be used to calculate the required volume.
   
   The combined input for the appliances located in the basement is calculated as follows:
   
   \[100,000 \text{ Btu/h (29 kW)} + 40,000 \text{ Btu/h (11.7 kW)} = 140,000 \text{ Btu/h (41 kW)}\]

   Using Table F 103.0 the required volume for a 140,000 Btu/h (41 kW) water heater is 7000 cubic feet (198.22 m\(^3\)).

3. **Conclusion:**
   
   The indoor volume is insufficient to supply combustion air since the total of 3600 cubic feet (101.94 m\(^3\)) does not meet the required volume of 7000 cubic feet (198.22 m\(^3\)). Therefore, additional combustion air shall must be provided from the outdoors.

4. **Determine the ratio of the available volume to the required volume.**

   \[\frac{3600 \text{ cubic feet}}{7000 \text{ cubic feet}} = 0.51\]

5. **Determine the single outdoor combustion air opening size as if though all combustion air is to come from outdoors.** In this example, the combustion air opening directly communicates with the outdoors.

   \[\frac{140,000 \text{ Btu/h}}{3000 \text{ British thermal units per square inch (Btu/in}^2\text{)}} = 47 \text{ square inch (0.03 m}^2\text{)}\]

6. **Determine the minimum outdoor combustion air opening area.**

   \[0.49 \text{ (from Step 4) x 47 square inches (0.03 m}^2\text{)} = 23 \text{ square inches (0.01 m}^2\text{)}\]

   Section 701.7.3(3) requires the minimum dimension of the air opening should not be less than 3 inches (76 mm).
SUBSTANTIATION:
In accordance with IAPMO Governing Consensus Project, Appendix F is being revised to the latest edition of NFPA 54-2018.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 178
UMC 2021  Section: Table 1701.1, Table 1701.2

SUBMITTER: Ladan Bulookbashi
Air Conditioning, Heating and Refrigeration Institute (AHRI)

RECOMMENDATION:
Revise text

### TABLE 1701.1
REFERENCED STANDARDS

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<td>AHRI 700-2016a 2017a</td>
<td>Specifications for Refrigerants</td>
<td>Refrigerants</td>
<td>1104.7, 1104.7.3</td>
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(portion of table not shown remains unchanged)

Note: AHRI 700 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

### TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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SUBSTANTIATION:

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 179
UMC 2021  Section: Table 1701.2

SUBMITTER: Jonathan Esslinger
American Society of Civil Engineers (ASCE)

RECOMMENDATION:
Revise text

TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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(portion of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the American Society of Civil Engineers (ASCE) standards that are referenced in Table 1701.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 180
UMC 2021  Section: Table 1701.1 and Table 1701.2

SUBMITTER: Connor Barbaree
ASHRAE

RECOMMENDATION:
Revise text

### TABLE 1701.1
**REFERENCED STANDARDS**

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<tr>
<td>ASHRAE Handbook-2013 2017</td>
<td>Fundamentals</td>
<td>Climatic Conditions</td>
<td>Figure 803.1.2(6)</td>
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(portion of table not shown remain unchanged)

**Note:** The ASHRAE Handbook does not meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

### TABLE 1701.2
**STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES**

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<td>ASHRAE 55-2013 2017</td>
<td>Thermal Environmental Conditions for Human Occupancy</td>
<td>Miscellaneous</td>
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**SUBSTANTIATION:**
The above revisions reflect the latest updates to the ASHRAE standards that are referenced in Table 1701.1 and Table 1701.2.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
**Proposals**

**Edit Proposal**

**Item #: 181**

**UMC 2021**  Section: Table 1701.1 and Table 1701.2

**SUBMITTER:** Carlton Ramcharran, Angel Guzman  
American Society of Mechanical Engineering (ASME)

**RECOMMENDATION:**  
Revise text

### TABLE 1701.1  
REFERENCED STANDARDS

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<td>ASME B16.3-2011</td>
<td>Malleable Iron Threaded Fittings: Classes 150 and 300</td>
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<td>ASME B16.5-2013</td>
<td>Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch</td>
<td>Fittings</td>
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<td>Forged Fittings, Socket-Welding and Threaded</td>
<td>Fittings</td>
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<td>ASME B16.20-2012</td>
<td>Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral-Wound, and Jacketed</td>
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<td>1308.5.11.2</td>
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<td>ASME B16.21-2012</td>
<td>Nonmetallic Flat Gaskets for Pipe Flanges</td>
<td>Fuel Gas Piping</td>
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<td>ASME B16.23-2012</td>
<td>Cast Copper Alloy Solder Joint Drainage Fittings</td>
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<td>ASME B16.24-2012</td>
<td>Cast Copper Alloy Pipe Flanges, and Flanged Fittings, and Valves: Classes 150 and 300</td>
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<td>Table 1210.1, 1308.5.10.2</td>
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<td>Large Diameter Steel Flanges: NPS 26 Through NPS 60 Metric/Inch</td>
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<td>ASME BPVC Section I-2015</td>
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<td>Boilers</td>
<td>1002.1(1), Table 1003.2.1</td>
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<td>Rules for Construction of Heating Boilers</td>
<td>Boilers</td>
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<td>Rules for Construction of Pressure Vessels - Division 1</td>
<td>Pressure Vessels</td>
<td>1002.1, 1004.3, 1112.10.1, 1112.13, 1113.1, 1115.4, 1115.4.1, 1117.1(2), 1117.1(3), 1117.2, 1209.4</td>
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Note: The ASME Standards meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

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<td>Flexible Water Connectors</td>
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<td>ASME B16.33-2012 (R2017)</td>
<td>Manually Operated Metallic Gas Valves for Use in Gas Piping Systems up to 175 psi (Sizes NPS 1/2 through NPS 2)</td>
<td>Valves</td>
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SUBSTANTIATION:
The above revisions reflect the latest updates to the American Society of Mechanical Engineering (ASME) standards that are referenced in Table 1701.1 and Table 1701.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 182
UMC 2021  Section: Table 1701.1

SUBMITTER: Conrad L Jahrling
ASSE International

RECOMMENDATION:
Add new text

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<td>ASSE 1079-2012</td>
<td>Dielectric Pipe Fittings</td>
<td>Fittings</td>
<td>1211.14.1</td>
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Note: ASSE 1079 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The standard is already referenced in section 1211.14.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26
VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
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<td>Threadless Copper Pipe, Standard Sizes</td>
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<td>Hot-Surface Performance of High-Temperature Thermal Insulation</td>
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<td>Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40</td>
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<td>ASTM D2513-20144-2016a</td>
<td>Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings</td>
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<td>1308.5.4, 1308.5.4.2.2, 1308.5.9.2, 1310.1.7.1(1), Table 1210.1</td>
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<td>ASTM D2846/D2846M-2014 2017b</td>
<td>Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems</td>
<td>Piping</td>
<td>1211.2(2), 1211.3(2), Table 1210.1</td>
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<td>Surface Burning Characteristics of Building Materials</td>
<td>Miscellaneous</td>
<td>508.3.4, 602.2, 604.1.2, 1201.2</td>
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<td>ASTM E814-2013a (R2017)</td>
<td>Fire Tests of Penetration Firestop Systems</td>
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<td>507.4.4, 507.4.5</td>
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<td>Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40</td>
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<td>Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes</td>
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<td>ASTM A568/A568M-2015 2017a</td>
<td>Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for</td>
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<td>Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process</td>
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SUBSTANTIATION:
The above revisions reflect the latest updates to the ASTM standards that are referenced in Table 1701.1 and Table 1701.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 184
UMC 2021  Section: Table 1701.1

SUBMITTER: Annette Alonso
American Welding Society (AWS)

RECOMMENDATION:
Revise text

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Note: AWS A5.8 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
The above revisions reflect the latest updates to the American Welding Society (AWS) standards that are referenced in Table 1701.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 185
UMC 2021  Section: Table 1701.1

SUBMITTER: Paul Olson
American Water Works Association (AWWA)

RECOMMENDATION:
Revise text

### TABLE 1701.1
REFERENCED STANDARDS

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<td>AWWA C901-20082017</td>
<td>Polyethylene (PE) Pressure Pipe and Tubing, ⅛ ⅜ in. (43 19 mm) Through 3 in. (76 mm) for Water Service</td>
<td>Piping, Plastic</td>
<td>Table 1210.1</td>
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(portion of table not shown remain unchanged)

Note: AWWA C901 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
The above revisions reflect the latest updates to the American Water Works Association (AWWA) standards that are referenced in Table 1701.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
**TABLE 1701.1**  
**REFERENCED STANDARDS**

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<tr>
<td>CSA B137.1-2013 2017</td>
<td>Polyethylene (PE) Pipe, Tubing, and Fittings for Cold-Water Pressure Services</td>
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<td>CSA B137.2-2013 2017</td>
<td>Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Applications</td>
<td>Piping, Plastic</td>
<td>Table 1210.1</td>
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<td>CSA B137.3-2013 2017</td>
<td>Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications</td>
<td>Piping, Plastic</td>
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<td>CSA B137.5-2013 2017</td>
<td>Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications</td>
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<td>CSA B137.6-2013 2017</td>
<td>Chlorinated Polyvinylchloride (CPVC) Pipe, Tubing, and Fittings for Hot- and Cold-Water Distribution Systems</td>
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<td>CSA B137.9-2013 2017</td>
<td>Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure-Pipe Systems</td>
<td>Piping</td>
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<td>CSA B137.10-2013 2017</td>
<td>Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Composite Pressure-Pipe Systems</td>
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<td>CSA B137.11-2013 2017</td>
<td>Polypropylene (PP-R) Pipe and Fittings for Pressure Applications</td>
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<td>CSA B137.18-2013 2017</td>
<td>Polyethylene of Raised Temperature Resistance (PE-RT) Tubing Systems for Pressure Applications</td>
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<td>CSA Z21.10.1-2014 2017</td>
<td>Gas Water Heaters-, Volume I, Storage Water Heaters with Input Ratings of 75,000 Btu Per Hour or Less (same as CSA 4.1)</td>
<td>Fuel Gas, Appliances</td>
<td>Table 1203.2</td>
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<td>CSA Z21.10.3-2015 2017</td>
<td>Gas-Fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous (same as CSA 4.3)</td>
<td>Fuel Gas, Appliances</td>
<td>Table 1203.2</td>
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<td>CSA Z21.93-2013 2017</td>
<td>Excess Flow Valves for Natural and LP Propane Gas with Pressures up to 5 psig (same as CSA 6.30)</td>
<td>Fuel Gas</td>
<td>1309.1</td>
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<tr>
<td>CSA Z83.4-2015</td>
<td>Non-Recirculating Direct Gas-Fired Industrial Air Heaters</td>
<td>Air Heaters, Non-</td>
<td>914.1</td>
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2017 Heating and Forced Ventilation Appliances for Commercial and Industrial Application (same as CSA 3.7) Recirculating, Non-Recirculating Heaters

CSA Z83.18-2015 Recirculating Direct Gas-Fired Industrial Air Heaters Heating and Forced Ventilation Appliances for Commercial and Industrial Applications Air Heaters, Industrial Heaters, Recirculating 915.1

(portion of table not shown remain unchanged)

Note: The CSA Standards meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

**TABLE 1701.2**

**STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES**

<table>
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<th>APPLICATION</th>
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<td>ASME A112.18.6/CSA B125.6-2009 (R2014) 2017</td>
<td>Flexible Water Connectors</td>
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<tr>
<td>CSA/IGSHPA C448-2016</td>
<td>Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings</td>
<td>Miscellaneous</td>
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<tr>
<td>CSA Z21.5.1-2016-2017</td>
<td>Gas Clothes Dryers-, Volume I, Type 1 Clothes Dryers (same as CSA 7.1)</td>
<td>Fuel Gas, Appliances</td>
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<tr>
<td>CSA Z21.11.2-2014-2016</td>
<td>Gas-Fired Room Heaters, Volume II, Unvented Room Heaters</td>
<td>Room Heaters, Unvented Heaters</td>
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<td>CSA Z21.13-2014/2017</td>
<td>Gas-Fired Low Pressure Steam and Hot Water Boilers (same as CSA 4.9)</td>
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<tr>
<td>CSA Z21.15b-2013 (R2014)</td>
<td>Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves (same as CSA 9.1b)</td>
<td>Fuel Gas</td>
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<td>CSA Z21.17a-2008 (R2014)</td>
<td>Domestic Gas Conversion Burners (same as CSA 2.7a)</td>
<td>Conversion Burner Installation, Gas Burners</td>
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<tr>
<td>CSA Z21.18b-2012 (R2012)-(R2016)</td>
<td>Gas Appliance Pressure Regulators (same as CSA 6.3b)</td>
<td>Appliance Regulators, Gas Refrigerators, Pressure Regulators</td>
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<td>CSA Z21.47-2014/2016</td>
<td>Gas-Fired Central Furnaces (same as CSA2.3)</td>
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<td>CSA Z21.50-2014/2016</td>
<td>Vented Gas Fireplaces, Decorative Gas Appliances (same as CSA 2.22)</td>
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<td>CSA Z21.58-2014/2018</td>
<td>Outdoor Cooking Gas Appliances (same as CSA 1.6)</td>
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<td>CSA Z21.71a-</td>
<td>Automatic Intermittent Pilot Ignition Systems for Field</td>
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<td>2005(R2007)</td>
<td>Installation Ignition, Pilot Ignition</td>
<td>Fuel Gas Appliances</td>
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<td>2008-2016</td>
<td>Vented Gas-Fired Space Heating Appliances (same as CSA 2.32)</td>
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<td>Vented Gas Fireplace Heaters (same as CSA 2.33)</td>
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<td>Gas Food Service Equipment (same as CSA 1.8)</td>
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<td>2014-2017</td>
<td>Gas-Fired High-Intensity Infrared Heaters (same as CSA 2.35a)</td>
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<tr>
<td>2016-2016</td>
<td>Gas-Fired Low-Intensity Infrared Heaters (same as CSA 2.34b)</td>
<td>Infrared Heaters, Low Intensity Heaters</td>
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(portion of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the Canadian Standards Association (CSA) standards that are referenced in Table 1701.1 and Table 1701.2.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
SUBMITTER: Kyle Thompson  
IAPMO

RECOMMENDATION:
Revise text

TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDS

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<thead>
<tr>
<th>DOCUMENT NUMBER</th>
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<tr>
<td>IAPMO PS 117-2012ae-2017</td>
<td>Press and Nail Connections</td>
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(portion of table not shown remain unchanged)

SUBSTANTIATION:  
The above revisions reflect the latest updates to the IAPMO PS standards that are referenced in Table 1701.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  
AFFIRMATIVE: 25  
NOT RETURNED: 1  
HOWARD
Item #: 188
UMC 2021  Section: Table 1701.1

SUBMITTER: Eric Smith
International Institute of Ammonia Refrigeration (IIAR)

RECOMMENDATION:
Revise text

### TABLE 1701.1
REFERENCED STANDARDS

<table>
<thead>
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<th>STANDARD NUMBER</th>
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<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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<tr>
<td>IIAR 3-2012 2017</td>
<td>Ammonia Refrigeration Valves</td>
<td>Ammonia Refrigeration Systems</td>
<td>1102.2</td>
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</table>

(portion of table not shown remain unchanged)

**Note:** IIAR 3 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the IIAR standards that are referenced in Table 1701.1.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**  
AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 189
UMC 2021  Section: Table 1701.2

SUBMITTER: David Thompson
Manufacturers Standardization Society (MSS)

RECOMMENDATION:
Revise text

TABLE 1701.2
REFERENCED STANDARDS

<table>
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<th>STANDARD NUMBER</th>
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<td>MSS SP-67-2011</td>
<td>Butterfly Valves</td>
<td>Valves</td>
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(portion of table not shown remains changed)

SUBSTANTIATION:
The above revisions reflect the latest updates to the MSS standards that are referenced in Table 1701.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  
AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 190
UMC 2021  Section: Table 1701.1 and Table 1701.2

SUBMITTER: Laura Moreno
National Fire Protection Association (NFPA)

RECOMMENDATION: Revise text

### TABLE 1701.1 REFERENCED STANDARDS

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<thead>
<tr>
<th>STANDARD NUMBER</th>
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<tr>
<td>NFPA 10-2013 2018</td>
<td>Portable Fire Extinguishers</td>
<td>Fire Extinguishing</td>
<td>513.11, 513.11.1, 513.12, 517.7.4</td>
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<tr>
<td>NFPA 12-2015 2018</td>
<td>Carbon Dioxide Extinguishing Systems</td>
<td>Fire Extinguishing</td>
<td>513.2.3(1)</td>
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<tr>
<td>NFPA 30A-2015 2018</td>
<td>Motor Fuel Dispensing Facilities and Repair Garages</td>
<td>Miscellaneous</td>
<td>303.11.1</td>
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<tr>
<td>NFPA 37-2015 2018</td>
<td>Installation and Use of Stationary Combustion Engines and Gas Turbines</td>
<td>Generators</td>
<td>1602.1, 1602.3</td>
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<td>NFPA 68-2013 2018</td>
<td>Explosion Protection by Deflagration Venting</td>
<td>Product Conveying Ducts</td>
<td>505.3.3</td>
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<tr>
<td>NFPA 90B-2015 2018</td>
<td>Installation of Warm Air Heating and Air-Conditioning Systems</td>
<td>HVAC</td>
<td>904.7</td>
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<td>NFPA 221-2015 2018</td>
<td>High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls</td>
<td>Building Fire Walls, Fire Barrier</td>
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<td>NFPA 1192-2015 2018</td>
<td>Recreational Vehicles</td>
<td>Fuel Gas Piping</td>
<td>1302.3</td>
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(portion of table not shown remain unchanged)

Note: The NFPA Standards meet the requirements for mandatory reference standards in accordance with
### TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

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<th>DOCUMENT TITLE</th>
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<tr>
<td>NFPA 30-2015 2018</td>
<td>Flammable and Combustible Liquids Code</td>
<td>Combustible Liquids, Flammable Liquids</td>
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<tr>
<td>NFPA 274-2013 2018</td>
<td>Test Method to Evaluate Fire Performance Characteristics of Pipe Insulation</td>
<td>Pipe Insulation</td>
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(portion of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the National Fire Protection Association (NFPA) standards that are referenced in Table 1701.1 and Table 1701.2.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:**  
- AFFIRMATIVE: 25  
- NOT RETURNED: 1  

HOWARD
Item #: 191
UMC 2021  Section: Table 1701.1

SUBMITTER: Jeremy Brown
NSF International

RECOMMENDATION:
Revise text

TABLE 1701.1
REFERENCED STANDARDS

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<td>NSF 358-1-2014</td>
<td>Polyethylene Pipe and Fittings for Water-Based Ground-Source “Geothermal” Heat Pump Systems</td>
<td>Piping, Plastic</td>
<td>Table 1210.1</td>
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(portion of table not shown remain unchanged)

Note: NSF 358-1 meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

SUBSTANTIATION:
The above revisions reflect the latest updates to the NSF standards that are referenced in Table 1701.1.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS:  AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Item #: 192
UMC 2021  Section: Table 1701.1

SUBMITTER: Eli Howard
SMACNA

RECOMMENDATION:
Revise text

### TABLE 1701.1
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<td>SMACNA-2006</td>
<td>HVAC Duct Construction Standards Metal and Flexible, 3rd 4th Edition</td>
<td>Ducts, Metal and Flexible</td>
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(portion of table not shown remains changed)

**Note:** HVAC Duct Construction Standards Metal and Flexible, 4th Edition meets the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the SMACNA standards that are referenced in Table 1701.1.

**COMMITTEE ACTION:** ACCEPT AS SUBMITTED

**TOTAL ELIGIBLE TO VOTE:** 26

**VOTING RESULTS:** **AFFIRMATIVE:** 25  **NOT RETURNED:** 1  **HOWARD**
**TABLE 1701.1**

**REFERRED STANDARDS**

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<td>UL 103-2010</td>
<td>Factory-Built Chimneys for Residential Type and Building Heating Appliances</td>
<td>Fuel Gas, Appliances</td>
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<td>Factory-Made Air Ducts and Air Connectors</td>
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<td>Closure Systems for Use with Rigid Air Ducts</td>
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<td>Closure Systems for Use with Flexible Air Ducts and Air Connectors</td>
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<td>Appliances, Commercial Cooking, Electric Appliances</td>
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<td>Commercial-Industrial Gas Burners</td>
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<td>Refrigeration Unit Coolers</td>
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<td>Refrigerating Units</td>
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<td>Type I Low-Temperature Venting Systems</td>
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<td>Power Ventilators <em>(with revisions through December 17, 2013)</em></td>
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<td>Exhaust Hoods for Commercial Cooking Equipment <em>(with revisions through November 5, 2013)</em></td>
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<td>Test for Surface Burning Characteristics of Building Materials <em>(with revisions through August 12, 2013)</em></td>
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<td>Motor Operated Water Pumps <em>(with revisions through February 22, 2017)</em></td>
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<td>Heating, Water Supply, and Power Boilers - Electric <em>(with revisions through December 9, 2013)</em></td>
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<td>Household Electric Ranges <em>(with revisions through April 6, 2016)</em></td>
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<td>Commercial Dishwashers <em>(with revisions through September 20, 2017)</em></td>
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<td>Microwave Cooking Appliances <em>(with revisions through November 18, 2015)</em></td>
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<td>Grease Filters for Exhaust Ducts <em>(with revisions through January 13, 2012)</em></td>
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<td>Electric Commercial Clothes-Drying Equipment <em>(with revisions through October 17, 2012)</em></td>
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<td>UL 1812-2013</td>
<td>Ducted Heat Recovery Ventilators <em>(with revisions through April 17, 2014)</em></td>
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<tr>
<td>UL 1815-2012</td>
<td>Nonducted Heat Recovery Ventilators <em>(with revisions through April 17, 2014)</em></td>
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<tr>
<td>UL 1820-2004</td>
<td>Fire Test of Pneumatic Tubing for Flame and Smoke Characteristics <em>(with revisions through May 10, 2013)</em></td>
<td></td>
<td>Surface Burning Test, Pneumatic Tubing</td>
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<tr>
<td>UL 1887-2004</td>
<td>Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics <em>(with revisions through May 3, 2013)</em></td>
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<td>Surface Burning Test, Fire Sprinkler Pipe</td>
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<tr>
<td>UL 1978-2010</td>
<td>Grease Ducts <em>(with revisions through September 19, 2014)</em></td>
<td></td>
<td>Ducts, Grease</td>
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<tr>
<td>UL 1996-2009</td>
<td>Electric Duct Heaters <em>(with revisions through June 13, 2014)</em></td>
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<td>Duct Heaters</td>
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<tr>
<td>UL 2021-2015</td>
<td>Fixed and Location-Dedicated Electric Room Heaters <em>(with revisions through December 14, 2016)</em></td>
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<td>Product, Heating, Electric</td>
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<tr>
<td>UL 2158A-2013</td>
<td>Clothes Dryer Transition Duct <em>(with revisions through April 18, 2017)</em></td>
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<td>Clothes Dryer Exhaust</td>
</tr>
<tr>
<td>UL 2518-20052016</td>
<td>Outline of Investigation for Air Dispersion Systems Materials <em>(with revisions through April 18, 2017)</em></td>
<td></td>
<td>Duct Systems</td>
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<tr>
<td>UL 60335-2-40-20122017</td>
<td>Household and Similar Electrical Appliances - Safety Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers</td>
<td></td>
<td>Appliances</td>
</tr>
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</table>
Note: The UL Standards meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO's Regulations Governing Committee Projects.

### TABLE 1701.2

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
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<tbody>
<tr>
<td>UL 21-2014</td>
<td>LP-Gas Hose (with revisions through September 29, 2015 July 28, 2017)</td>
<td>Hose, LPG Hose</td>
</tr>
<tr>
<td>UL 125-2014</td>
<td>Flow Control Valves for Anhydrous Ammonia and LP-Gas (with revisions through February 18, 2015 January 12, 2018)</td>
<td>Fuel Gas</td>
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<tr>
<td>UL 132-2015</td>
<td>Safety Relief Valves for Anhydrous Ammonia and LP-Gas (with revisions through February 17, 2016 January 12, 2018)</td>
<td>Fuel Gas</td>
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<tr>
<td>UL 180-2012</td>
<td>Liquid-Level Gauges for Oil Burner Fuels and Other Combustible Liquids (with revisions through May 12, 2017)</td>
<td>Gauges, Level Gauges</td>
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<tr>
<td>UL 252-2017</td>
<td>Compressed Gas Regulators (with revisions through January 28, 2017)</td>
<td>Fuel Gas</td>
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<tr>
<td>UL 343-2008</td>
<td>Pumps for Oil-Burning Appliances (with revisions through June 12, 2013 December 14, 2017)</td>
<td>Fuel Gas, Appliances</td>
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<tr>
<td>UL 525-2008</td>
<td>Flame Arresters (with revisions through August 10, 2012 October 13, 2017)</td>
<td>Flame Arresters</td>
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<tr>
<td>UL 565-2013</td>
<td>Liquid-Level Gauges for Anhydrous Ammonia and LP-Gas (with revisions through December 13, 2017)</td>
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<td>UL 569-2013</td>
<td>Pigtails and Flexible Hose Connectors for LP-Gas (with revisions through July 28, 2017)</td>
<td>Fuel Gas</td>
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<tr>
<td>UL 842-2015</td>
<td>Valves for Flammable Fluids (with revisions through October 27, 2017)</td>
<td>Valves</td>
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<tr>
<td>UL 1453-2016</td>
<td>Electric Booster and Commercial Storage Tank Water Heaters (with revisions through March 9, 2017)</td>
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</table>

SUBSTANTIATION:
The above revisions reflect the latest updates to the Underwriters Laboratories, Inc. (UL) standards that are referenced in Table 1701.1 and Table 1701.2.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25 NOT RETURNED: 1 HOWARD
Item #: 194
UMC 2021  Section: Table 1701.2

SUBMITTER: April Trafton
Donald Dickerson Associates

RECOMMENDATION:
Add new text

TABLE 1701.2
STANDARDS, PUBLICATIONS, PRACTICES, AND GUIDES

<table>
<thead>
<tr>
<th>DOCUMENT NUMBER</th>
<th>DOCUMENT TITLE</th>
<th>APPLICATION</th>
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</thead>
<tbody>
<tr>
<td>IAPMO IGC 315-2016</td>
<td>Water Manifold Systems</td>
<td>Fittings</td>
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<tr>
<td>IAPMO IGC 332-2017a</td>
<td>Hydronic Radiators</td>
<td>Miscellaneous</td>
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<tr>
<td>IAPMO IGC 327-2016</td>
<td>Flexible Metallic Expansion Joints for Pressure Systems</td>
<td>Joints</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)

SUBSTANTIATION:
The standards proposed for inclusion in Table 1701.2 are used to test and list multiple products from several different manufacturers. Inclusion of these standards in Table 1701.2 will help the end users of the code to determining if a product has been evaluated or is appropriately listed.

COMMITTEE ACTION: ACCEPT AS SUBMITTED

TOTAL ELIGIBLE TO VOTE: 26

VOTING RESULTS: AFFIRMATIVE: 25  NOT RETURNED: 1  HOWARD
Factory-Made Air Duct Task Group Report
UMC Factory-Made Air Duct Task Group Report

Roster:

<table>
<thead>
<tr>
<th>Member</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ralph Koerber (Chair)</td>
<td>Air Duct Council</td>
</tr>
<tr>
<td>Charles Stock</td>
<td>Spunstrand Inc.</td>
</tr>
<tr>
<td>David Dias</td>
<td>Sheet Metal Workers Local 104</td>
</tr>
<tr>
<td>David Mann</td>
<td>California State Pipe Trades Council</td>
</tr>
<tr>
<td>Donald Surrena</td>
<td>National Association of Home Builders</td>
</tr>
<tr>
<td>Jesus Echevarria</td>
<td>PURITY AIR HVAC, LLC</td>
</tr>
<tr>
<td>John Taecker</td>
<td>Underwriters Laboratories (UL)</td>
</tr>
<tr>
<td>Lyle Co</td>
<td>Coe and Company Construction Services</td>
</tr>
<tr>
<td>Phil Ribbs</td>
<td>PHR Consultants</td>
</tr>
<tr>
<td>Todd Gottshall</td>
<td>Western Allied Mechanical, Inc.</td>
</tr>
<tr>
<td>William Chapin</td>
<td>Profession Code Consulting, LLC</td>
</tr>
</tbody>
</table>

Overview:

Various proposals and comments were being submitted by the industry relating to “factory-made air ducts.” Some were requesting for a complete removal of the term “factory-made air ducts” and others were requesting for a definition for “factory-made” to be added to the UMC. The industry was confused as what duct materials were considered or included as “factory-made air ducts.”

On May 4, 2017 in Anaheim California, the UMC TC Chair, April Trafton, approved the formation of a Factory-Made Air Duct Task Group to address the concerns of the industry.

The scope of the Factory-Made Air Duct Task Group is to review how the term “factory-made air ducts” is referenced throughout the Uniform Mechanical Code (UMC) and to review products that fall under this category. The objective is to provide an in-depth analysis and develop recommendations for the UMC Technical Committee for consideration.

The Task Group met three times via teleconference on February 7, 2018, February 22, 2018 and March 8, 2018. Proposed recommendations were obtained from members of the task group and any interested parties.

The Task Group voted to revise the language in Chapter 6 relating to “factory-made air ducts” to include provisions for separate duct materials such as metallic ducts and nonmetallic ducts. The nonmetallic materials included phenolic, gypsum, air dispersion systems, and other materials. The Task Group indicated that such recommendations will allow other acceptable duct materials to be added to the code for enforcement purposes.
Recommendation:

602.3 Metallic. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Flexible metallic ducts shall comply with UL 181.

602.4 Nonmetallic Ducts. Nonmetallic ducts shall comply with Section 602.4.1, Section 602.4.2, Section 602.4.3 or Section 602.4.4.

   602.4.1 Phenolic. Phenolic duct, plenum, or fitting material shall comply with UL 181. Ducts, plenums, or fittings of phenolic shall be constructed in accordance with SMACNA Phenolic Duct Construction Standards or the conditions of its listing.

   602.4.2 Gypsum. Where gypsum products are exposed in ducts or plenums, the air temperature shall be restricted to a range from 50°F (10°C) to 125°F (52°C), and moisture content shall be controlled so that the material is not adversely affected. All gypsum products shall have a mold or mildew resistant surface. For the purpose of this section, gypsum products shall not be exposed in supply ducts.

   602.4.3 Air Dispersion Systems. Air dispersion systems shall be listed and labeled in accordance with UL 2518.

   602.4.4 Other Materials. Flexible and rigid ducts, plenums, or fittings for use in heating, ventilation, and air conditioning systems of other nonmetallic materials listed and labeled to UL 181 shall be permitted.

   Exception: Plastic ducts shall comply with Section 603.6.

602.6 Factory-Made Air Ducts. Factory-made air ducts shall be approved for the use intended or shall be in accordance with the requirements of UL 181. Each portion of a factory-made air duct system shall be identified by the manufacturer with a label or other identification indicating compliance with its class designation.

(renumber remaining sections)

603.0 Installation of Ducts.

603.1 General. Air ducts shall be installed in accordance with this Chapter and the installation instructions. The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

   603.1.1 Pressure Classification. The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

   603.1.2 Air Temperature. The temperature of the air to be conveyed in a duct shall not exceed 250°F (121°C).

   603.1.3 Protection. Air ducts, other than plastic ducts, shall be installed with not less than 4 inches (102 mm) of separation from earth, except where installed as a liner inside of concrete, tile, or metal pipe and shall be protected from physical damage.

   603.1.4 Vertical Risers. Ducts listed and labeled to UL 181 shall not be used for vertical risers in air-duct systems serving more than two stories.

   603.1.5 Penetrations. Ducts listed and labeled to UL 181 shall not penetrate a fire-resistance-rated assembly or construction.

603.3 Metal Ducts. Ducts shall be supported at each change of direction and in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Riser ducts shall be held in place by means of metal straps or angles and channels to secure the riser to the structure.

   Metal ducts shall be installed with not less than 4 inches (102 mm) separation from earth. Ducts shall be installed in a building with clearances that will retain the full thickness of fireproofing on structural members.
**603.4 Factory-Made Air Ducts.** Factory-made air ducts shall be listed and labeled in accordance with UL 181 and installed in accordance with the terms of their listing, the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Factory-made air ducts shall not be used for vertical risers in air duct systems serving more than two stories and shall not penetrate a fire-resistance-rated assembly or construction.

Factory-made air ducts shall be installed with not less than 4 inches (102 mm) of separation from earth, except where installed as a liner inside of concrete, tile, or metal pipe and shall be protected from physical damage.

The temperature of the air to be conveyed in a duct shall not exceed 250°F (121°C). Flexible air connectors shall not be permitted.

**603.4.1 Length Limitation.** Factory-made flexible air ducts and connectors shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

**Exception:** Residential occupancies.

(renumber remaining sections)

**603.5 Flexible Air Ducts.** Flexible air ducts shall comply with UL 181, and shall be installed in accordance with the manufacturer’s installation instructions and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Flexible air duct installations shall comply with the following:

1. Ducts shall be installed using the minimum required length to make the connection.
2. Horizontal duct runs shall be supported at not more than 4 feet (1219 mm) intervals.
3. Vertical risers shall be supported at not more than 6 feet (1829 mm) intervals.
4. Sag between support hangers shall not exceed ½ inch (12.7 mm) per foot (305 mm) of support spacing.
5. Supports shall be rigid and shall be not less than 1 ½ inches (38 mm) wide at point of contact with the duct surface.
6. Duct bends shall be not less than one duct diameter bend radius.
7. Screws shall not penetrate the inner liner of non-metallic flexible ducts unless permitted in accordance with the manufacturer’s installation instructions.
8. Fittings for attaching non-metallic ducts shall be beaded and have a collar length of not less than 2 inches (51 mm) for attaching the duct.

**Exception:** A bead shall not be required where metal worm-gear clamps are used or where attaching metallic ducts using screws in accordance with the manufacturer’s installation instructions.

9. Duct inner liner shall be installed at not less than 1 inch (25.4 mm) on the collar and past the bead prior to the application of the tape and mechanical fastener. Where mastic is used instead of tape, the mastic shall be applied in accordance the mastic manufacturer’s instructions.
10. Duct outer vapor barriers shall be secured using two wraps of approved tape. A mechanical fastener shall be permitted to be used in place of, or in combination with, the tape.
11. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction.
12. The temperature of the air to be conveyed in a flexible air duct shall not exceed 250°F (121°C).
13. Flexible Air ducts shall be sealed in accordance with Section 603.10.

**603.5.1 Length Limitation.** Flexible air ducts shall be not more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings. Flexible air ducts shall be permitted to be used as an elbow at a terminal device.

**Exception:** Residential occupancies.

**603.5.2 Flexible Air Connectors.** Flexible air connectors shall not be permitted.

**603.8 Support of Ducts.** Installers shall provide the manufacturer’s field fabrication and installation instructions.

Factory-made air ducts that are in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Other ducts shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible or the manufacturer’s installation instructions.

(remaining text unchanged)
603.10 Joints and Seams of Ducts. Joints and seams for duct systems shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Joints of duct systems shall be made substantially airtight by means of tapes, mastics, gasketing, or other means. Crimp joints for round ducts shall have a contact lap of not less than 1½ inches (38 mm) and shall be mechanically fastened by means of not less than three sheet-metal screws equally spaced around the joint, or an equivalent fastening method.

603.10.1 Closure Systems. Joints and seams and reinforcements, for factory-made air ducts and plenums listed and labeled to UL 181, shall comply with the conditions of prior approval be in accordance with the manufacturer's installation instructions that shall accompany the product. Closure systems for sealing factory-made air ducts and plenums shall be listed and labeled in accordance with UL 181A or UL 181B, and marked in accordance with Table 603.10.1.

(renumber remaining sections)

604.0 Insulation of Ducts.
604.1 General. Air ducts conveying air at temperatures exceeding 140°F (60°C) shall be insulated to maintain an insulation surface temperature of not more than 140°F (60°C). Factory-made air ducts and insulations intended for installation shall be legibly printed with the name of the manufacturer, the thermal resistance (R) value at installed thickness, flame-spread index, and smoke developed index of the composite material. Internal duct liners and insulation shall be installed in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.

(remaining text unchanged)

Substantiation:
The term “factory-made air ducts” is vague and ambiguous in regard to which products are included within the category. Therefore, the appropriate materials have been added to Section 602.3-602.4, and the specific installation requirements have been added to Section 603.1 for clarity.

Section 603.4 (Factory Made Air Ducts) has been split into two categories; Section 602.3 (Metallic) and Section 602.4 (Nonmetallic). Section 602.3 will provide the minimum requirements for metallic ducts. Section 602.4 specifies the requirements for phenolic, gypsum and other materials.

The phrase “Metal ducts shall be installed with not less than 4 inches (102 mm) separation from earth” is being removed from Section 603.3, since this requirement is already stated under the new general Section 603.1.3 (Protection), which applies to all duct materials except plastic ducts.

Section 603.4.1 (Length Limitation) has been relocated under the “Flexible Air Ducts” section, as this requirement only applies to flexible air ducts.

Section 603.8 (Support of Ducts) is being modified for clarity as all air ducts are supported in accordance SMACNA or the manufacturer’s installation instructions, not only air ducts that are in accordance with UL 181.

Section 603.10 (Joints and Seams of Ducts) was separated into its own respective section, 603.10.1 (Closure Systems), as closure systems have unique requirements that do not necessarily apply to joints and seams.

Under Section 604.1, the term “factory-made air ducts” is being removed, as these insulation requirements apply to all air ducts.
Technical Correlating Committee Report
2018 IAPMO Technical Correlation Committee (TCC) Report
Correlation Items Between the UPC and UMC

TCC ITEM # 001

<table>
<thead>
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<th>2021 UNIFORM PLUMBING CODE</th>
<th>2021 UNIFORM MECHANICAL CODE</th>
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<tr>
<td>ITEM # 049, 157</td>
<td>ITEM # 069, 044, 145</td>
</tr>
</tbody>
</table>

RECOMMENDATION:

Item # 049

509.4.2 Plastic Vent Joints. Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer’s installation instructions. Plastic pipe venting materials listed and labeled in accordance with ANSI/UL 1738 shall be installed in accordance with the vent manufacturer’s installation instructions. Where primer is required, it shall be of a contrasting color. [NFPA 54:12.5.3]

Item # 069

802.4.2 Plastic Vent Joints. Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer’s installation instructions. Plastic pipe venting materials listed and labeled in accordance with UL 1738 shall be installed in accordance with the vent manufacturer’s installation instructions. Where primer is required, it shall be of a contrasting color. [NFPA 54:12.5.3]

Item # 044

509.1 Grease Removal Devices. Listed grease filters or other listed grease removal devices intended for use with commercial cooking operations shall be provided. Listed grease filters and grease removal devices that are removable but not an integral component of a specific listed exhaust hood shall be listed in accordance with ANSI/UL 1046 and shall be designated on the filter. [NFPA 96:6.1.1, 6.1.2]

517.3.1.1 Equipment with Solid Fuel for Flavoring. Gas-operated equipment utilizing solid fuel for flavoring that meets all the following conditions shall not be required to have a separate exhaust system:

1. The solid fuel holder (smoker box) shall be listed with the gas-operated equipment.
2. The solid fuel holder shall be located underneath the gas burners.
3. Spark arresters conforming with Section 517.1.6 shall be provided.
4. The maximum quantity of solid fuel consumed shall not exceed 1 pound (0.45 kg) per hour per 100 000 Btu/hr (29 kW) of gas burner capacity.
5. The gas-operated equipment shall be protected by a fire suppression system listed for the equipment, including the solid fuel holder.
6. Gas-operated equipment with integral solid fuel holder(s) intended for flavoring, such as radiant charbroiler(s), shall comply simultaneously with the requirements of ANSI/UL 300 that address the gas radiant charbroiler(s) and mesquite wood charbroiler(s).
7. A fire suppression system nozzle(s) shall be installed to protect the solid fuel holder.
8. The fire suppression system shall be designed and installed to protect the entire cooking operation.
1208.6.11.2 Pipe Joints. Schedule 40 and heavier pipe joints shall be threaded, flanged, brazed, welded, or assembled with press-connect fittings listed to ANSI CSA LC 4/CSA 6.32.

(1) Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C).
(2) Brazing alloys shall not contain more than 0.05 percent phosphorus.

1208.6.11.3 Copper Tubing Joints. Copper tubing joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1000°F (538°C), or shall be assembled with press-connect fittings listed to ANSI CSA LC 4/CSA 6.32, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.7.2]

1208.6.11.4 Stainless Steel Tubing Joints. Stainless steel joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1000°F (538°C), or assembled with press-connect fittings listed to ANSI CSA LC 4/CSA 6.32, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys and fluxes shall be recommended by the manufacturer for use on stainless steel alloys. [NFPA 54:5.6.7.3]

1211.3 Arc-Resistant Jacketed CSST. CSST listed with an arc resistant jacket or coating system in accordance with CSA LC 1 shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST component of a piping system does not have an arc-resistant jacket or coating system, the bonding requirements of Section 1211.2 shall apply. Arc-resistant jacketed CSST shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.12.3]
### Substantiation:

The language in UPC Item # 049 and # 157, Sections 509.4.2, and 1208.6.11.2 – 1208.6.11.4 are being revised to correlate with the language approved by the UMC TC for Item # 069, Section 802.4.2 with regards to the term “ANSI” being part of the standard title as referenced throughout the UPC and UMC.

Furthermore, the language in UMC Item # 044 and # 145, Sections 509.1, 517.3.1.1, 1308.5.8.2-1308.5.8.4, and 1311.3 are being revised to correlate with the language approved by the UPC TC for Item # 157, Section 1211.3 with regards to the term “ANSI” being part of the standard title as referenced throughout the UPC and UMC.

The following is provided for informational purpose only:

**Item # 047, not shown above, was rejected by the UMC TC for the following reason:** “The proposed change is unnecessary as there are other standards that are also ANSI standards within the code that do not include ANSI in the title.”

**The substantiation provided for proposal Item # 047 of the UMC is as follows:** “The current reference to AC-CA Manual D is updated to reflect its ANSI standard designation. This edition is unchanged from that currently referenced in the 2018 UMC.”

Additionally, the references to “ANSI LC 4/CSCA 6.32” and “ANSI LC 1/CSCA 6.26” are being revised to correlate with the other references to similar standards in the UPC, UMC, and Table 1701.1. These CSA standards are referenced in Table 1701.1 and throughout the codes as “CSA LC 4” and “CSA LC 1.”

<table>
<thead>
<tr>
<th>Item</th>
<th>Accept recommendation as submitted</th>
<th>Reject the recommendation</th>
</tr>
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<tbody>
<tr>
<td>049</td>
<td>x</td>
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<tr>
<td>157</td>
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### TCC ITEM # 002

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<tr>
<td><strong>ITEM # 048</strong></td>
<td><strong>ITEM # 070</strong></td>
</tr>
</tbody>
</table>

#### RECOMMENDATION:

**509.0 Venting of Appliances.**

**509.5 Masonry, Metal, and Factory-Built Chimneys.** (remaining text unchanged)

**509.5.1 Factory-Built Chimneys.** (remaining text unchanged)

**509.5.1.2 Listing Requirements.** Factory-built chimneys shall comply with the requirements of UL 103 or UL 959. Factory-built chimneys for use with wood-burning appliances shall comply with the Type HT requirements of UL 103.  
[NFPA 211:6.1.3.1, 6.1.3.2]

**802.0 Venting of Appliances.**

**802.5 Masonry, Metal, and Factory-Built Chimneys.** (remaining text unchanged)

**802.5.1 Factory-Built Chimneys.** (remaining text unchanged)

**802.5.1.2 Listing Requirements.** Factory-built chimneys shall comply with the requirements of UL 103, or UL 959, or UL 2561. Factory-built chimneys for use with wood-burning appliances shall comply with the Type HT requirements of UL 103.  
[NFPA 211:6.1.3.1, 6.1.3.2]

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<tr>
<th><strong>X</strong></th>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
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</thead>
<tbody>
<tr>
<td><strong>Substantiation:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The language in UMC Item # 070, Section 802.5.1.2 is being revised to correlate with the action taken by the UPC TC for Item # 048, Section 509.5.1.2 regarding listing requirements for factory-built chimneys.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Committee Statement provided for rejecting proposal Item # 048 by the UPC TC is as follows: “The existing NFPA extract language should not be modified as it addresses the appropriate listing requirements for factory-built chimneys.”</td>
<td></td>
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<tr>
<td>The substantiation provided for proposal Item # 048 of the UPC is as follows: “Section 509.5.1.2 is being revised to include the correct standards for factory-built chimneys. This is consistent with current industry standards.”</td>
<td></td>
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<tr>
<td>The substantiation provided for proposal Item # 070 of the UMC is as follows: “Section 802.5.1.2 is being revised to include the correct standard for factory-built chimneys. This is consistent with current industry standards.”</td>
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TCC ITEM # 003

RECOMMENDATION:

1210.0 Gas Piping Installation.

1210.3 Concealed Piping in Buildings. (remaining text unchanged)

1210.3.1 Connections. Where gas piping is to be concealed, connections shall be of the following type:

(1) Pipe fittings such as elbows, tees, couplings, and right/left nipple/couplings.

(2) Joining tubing by brazing (see Section 1208.6.11.2).

(3) Press-connect fittings listed to ANSI/CSA LC 4/CSA 6.32 for use in concealed spaces or that have been demonstrated to sustain, without leakage, forces due to temperature expansion or contraction, vibration, or fatigue based on their geographic location, application, or operation.

(4) Where necessary to insert fittings in the gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a right/left nipple/coupling.

1310.0 Gas Piping Installation.

1310.3 Concealed Piping in Buildings. (remaining text unchanged)

1310.3.1 Connections. Where gas piping is to be concealed, connections shall be of the following type:

(1) Pipe fittings, such as elbows, tees, couplings, and right/left nipple/couplings.

(2) Joining tubing by brazing (see Section 1308.5.8.2).

(3) Press-connect fittings listed to CSA LC 4 for use in concealed spaces or that have been demonstrated to sustain, without leakage, forces due to temperature expansion or contraction, vibration, or fatigue based on their geographic location, application, or operation.

(4) Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a right/left nipple/coupling.

Accept recommendation as submitted.

Reject the recommendation.

Substantiation:

The language in UPC Item # 152, Section 1210.3.1(3) is being revised to correlate with UMC Item # 140, Section 1310.3.1(3) with regards to removing CSA LC 1, and specifying “press-connect fittings” as listed to CSA LC 4.

Additionally, the reference to “ANSI LC 4/CSA 6.32” in Item # 152, Section 1210.3.1(3) is being revised to correlate with the other references to similar standards in the UPC, UMC, and Table 1701.1. These CSA standards are referenced in Table 1701.1 and throughout the codes as “CSA LC 4.”

Furthermore, the language in UMC Item # 140, Section 1310.3.1(3) is being revised to correlate with the language in UPC Item # 152, Section 1210.3.1(3) with regards to press-connect fittings used in concealed spaces.

The Committee Statement provided for amending proposal Item # 152 by the UPC TC is as follows: “The current language is being added back as it is necessary to identify what is required for a concealed fitting.”

The substantiation provided for proposal Item # 152 of the UPC is as follows: “The current language has caused confusion of the fittings that are listed and approved for installation in concealed locations. The only fittings that are listed as such are included along with the standards they should be listed to. This language comes directly from NFPA 54 and provides a much clearer understanding for the building official what types of fitting shall be listed and to what standards they shall be listed to. The proposed language will remove confusion in the industry.”

The Committee Statement provided for amending proposal Item # 140 by the UMC TC is as follows: “The term “press-connect” is being added to clarify the type of fitting intended. Furthermore, CSA LC-1 is being removed as the standard does not apply for such application.”

The substantiation provided for proposal Item # 140 of the UMC is as follows: “The current language has caused confusion of the fittings that are listed and approved for installation in concealed locations. The only fittings that are listed as such are included along with the standards they should be listed to. This language comes directly from NFPA 54 and provides a much clearer understanding for the building official what types of fitting shall be listed and to what standards they shall be listed to. The proposed language will remove confusion in the industry.”
MEMORANDUM

TO: Technical Correlating Committee
FROM: Enrique Gonzalez, Staff Liaison
DATE: August 2, 2018
SUBJECT: Final Ballot Results for TCC Report

Dear 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
0 Ballot was not received by the final closing date of August 1, 2018.
(See voting results below for details)
0 Abstaining

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 3/4 affirmative.
2. In all cases, an affirmative vote of at least a simple majority of the total members eligible to vote is required.

All of the committee actions for the Technical Correlating Committee Report achieved the necessary 3/4 affirmative votes of returned ballots.

Please contact me with any questions or comments you may have at (909) 230-5535 or by email at enrique.gonzalez@iapmo.org.

Thank you.
## TCC FINAL BALLOT RESULTS - JULY 2018

### Ballot Name: TCC Item # 001 July 2018

**Total Votes:** 7

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### Ballot Name: TCC Item # 002 July 2018

**Total Votes:** 7

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### Ballot Name: TCC Item # 003 July 2018

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Part II

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CHAPTER 1
ADMINISTRATION

101.0 General.
101.1 Title. This document shall be known as the “Uniform Mechanical 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, repair, relocation, replacement, addition to, use, or maintenance of mechanical 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 mechanical code conflict with the requirements of the plumbing code, the plumbing 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 Installations. Mechanical 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 mechanical system.
102.3 Maintenance. Mechanical 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 mechanical systems. To determine compliance with this subsection, the Authority Having Jurisdiction shall be permitted to cause a mechanical system to be reinspected.

102.3.1 Commercial HVAC Systems. Commercial HVAC systems both existing and new, and parts thereof shall be inspected and maintained in operating condition in accordance with ASHRAE/ACCA 180. The owner or the owner’s designated agent shall be responsible for maintenance of mechanical systems and equipment. To determine compliance with this subsection, the Authority Having Jurisdiction shall be permitted to cause a HVAC system to be reinspected.

102.3.2 Residential HVAC Systems. Residential HVAC systems both existing and new, and parts thereof shall be inspected in accordance with ACCA 4 QM. The owner or the owner’s designated agent shall be responsible for maintenance of mechanical systems and equipment. To determine compliance with this subsection, the Authority Having Jurisdiction shall be permitted to cause a HVAC 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 mechanical 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 mechanical 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 mechanical system facilities or shall make such repairs or alterations as ordered by the Authority Having Jurisdiction.

102.6 Changes in Building Occupancy. Mechanical 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 mechanical system of a building and 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 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 in 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.

103.4 Right of Entry. Where it is necessary to make an inspection to enforce the provisions of this code, or where the Authority Having Jurisdiction has reasonable cause to believe that there exists in a building or upon a premises a condition or violation of this code that makes the building or premises unsafe, insanitary, dangerous, or hazardous, the Authority Having Jurisdiction shall be permitted to enter the building or premises at reasonable times to inspect or to perform the duties imposed upon the Authority Having Jurisdiction by this code, provided that where such building or premises is occupied, the Authority Having Jurisdiction shall present credentials to the occupant and request entry. Where such building or premises is unoccupied, the Authority Having Jurisdiction shall first make a reasonable effort to locate the owner or other person having charge or control of the building or premises and request entry. Where entry is refused, the Authority Having Jurisdiction has recourse to every remedy provided by law to secure entry.

Where the Authority Having Jurisdiction shall have first obtained an inspection warrant or other remedy provided by law to secure entry, no owner, occupant, or person having charge, care or control of a building or premises shall fail or neglect, after a request is made as herein provided, to promptly permit entry herein by the Authority Having Jurisdiction for the purpose of inspection and examination pursuant to this code.

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 mechanical 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 mechanical permit for each separate building or structure.

104.2 Exempt Work. A permit shall not be required for the following:

(1) A portable heating appliance, a portable cooling unit, or a portable evaporative cooler.

(2) A closed system of steam, hot, or chilled water piping within heating or cooling equipment regulated by this code.

(3) Replacement of a component part that does not alter its original approval and is in accordance with other applicable requirements of this code.

(4) Refrigerating equipment that is part of the equipment for which a permit has been issued pursuant to the requirements of this code.

(5) A unit refrigerating system.

Exemption from the permit requirements of this code shall not be deemed 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 with each application for a permit. The construction documents, computations, and specifications shall be prepared by, and the mechanical 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 mechanical 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 done in accordance with approved plans.

The Authority Having Jurisdiction shall be permitted to issue a permit for the construction of a part of a mechanical 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 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 mechanical 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 Extension. 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 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 or Revocation. The Authority Having Jurisdiction shall be permitted to, in writing, 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 is 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 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. Mechanical systems for which a permit is required by this code shall be inspected by the Authority Having Jurisdiction.

No mechanical 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. Mechanical systems regulated by this code shall not be connected to the energy fuel supply lines until authorized by the Authority Having Jurisdiction.

105.2 Required Inspections. New mechanical 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 mechanical system are 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 mechanical 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 mechanical systems 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 mechanical 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 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.** Mechanical 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 mechanical 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 the mechanical 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 mechanical 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 mechanical system or equipment 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 mechanical 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 mechanical 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 or 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 a 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 mechanical system to a building, structure, or equipment regulated by this code in case of 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 mechanical 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 mechanical 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 mechanical system after receiving such notice.

Where such mechanical 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 mechanical system design, construction, and maintenance and the public health aspects of mechanical 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
#### MECHANICAL PERMIT FEES

**Permit Issuance**
1. For the issuance of each permit................................................................. 1
2. For issuing each supplemental permit for which the original permit has not expired or been canceled or finalized.................................................. 1

**Unit Fee Schedule**

1. **Furnaces:**
   - For the installation or relocation of each forced-air or gravity-type furnace or burner, including ducts and vents attached to such appliance, not exceeding 100,000 British thermal units per hour (Btu/h) .............................................................................................................................. 1
   - For the installation or relocation of each forced-air or gravity-type furnace or burner, including ducts and vents attached to such appliance, exceeding 100,000 Btu/h .............................................................................................................................. 1
   - For the installation or relocation of each floor furnace, including vent ......................................................................................................................... 1
   - For the installation or relocation of each suspended heater, recessed wall heater, or floor-mounted unit heater .............................................................................................................................. 1

2. **Appliance Vents:**
   - For the installation, relocation, or replacement of each appliance vent installed and not included in an appliance permit .............................................................................................................................. 1

3. **Repairs or Additions:**
   - For the repair of, alteration of, or addition to each heating appliance, refrigeration unit, cooling unit, absorption unit, or each heating, cooling, absorption, or evaporative cooling system including installation of controls regulated by this code ........................................................................................................................................ 1

4. **Boilers, Compressors, and Absorption Systems:**
   - For the installation or relocation of each boiler or compressor, not exceeding 3 horsepower (hp), or each absorption system not exceeding 100,000 Btu/h .............................................................................................................................. 1
   - For the installation or relocation of each boiler or compressor exceeding 3 hp, not exceeding 15 hp, or each absorption system exceeding 100,000 Btu/h and including 500,000 Btu/h .............................................................................................................................. 1
   - For the installation or relocation of each boiler or compressor exceeding 15 hp, not exceeding 30 hp, or each absorption system exceeding 500,000 Btu/h, not exceeding 1,000,000 Btu/h .............................................................................................................................. 1
   - For the installation or relocation of each boiler or compressor exceeding 30 hp, not exceeding 50 hp, or for each absorption system exceeding 1,000,000 Btu/h, not exceeding 1,750,000 Btu/h .............................................................................................................................. 1
   - For the installation or relocation of each boiler or compressor exceeding 50 hp, or each absorption system exceeding 1,750,000 Btu/h .............................................................................................................................. 1

5. **Air Handlers:**
   - For each air-handling unit not exceeding 10,000 cubic feet per minute (cfm), including ducts attached thereto .............................................................................................................................. 1

6. **Evaporative Coolers:**
   - For each air-handling unit exceeding 10,000 cfm .............................................................................................................................. 1
   - For each evaporative cooler other than portable type .............................................................................................................................. 1

7. **Ventilation and Exhaust:**
   - For each ventilation fan connected to a single duct .............................................................................................................................. 1
   - For each ventilation system that is not a portion of a heating or air-conditioning system authorized by a permit .............................................................................................................................. 1
   - For the installation of each hood that is served by mechanical exhaust, including the ducts for such hood .............................................................................................................................. 1

8. **Incinerators:**
   - For the installation or relocation of each domestic-type incinerator .............................................................................................................................. 1
   - For the installation or relocation of each commercial or industrial-type incinerator .............................................................................................................................. 1
9. Miscellaneous:
   For each appliance or piece of equipment regulated by this code, but not classed in other appliance
categories, or for which no other fee is listed in this table................................................................................... 1

10. Fuel Gas Piping:
   Where Chapter 13 or Appendix B is applicable (See Section 101.2), permit fees for fuel-gas piping shall
be as follows:
   For each gas piping system of one to five outlets .................................................................................... 1
   For each additional gas piping system, per outlet .................................................................................... 1

11. Process Piping:
   For each hazardous process piping system (HPP) of one to four outlets ................................................... 1
   For each HPP piping system of five or more outlets, per outlet ................................................................. 1
   For each nonhazardous process piping system (NPP) of one to four outlets ........................................... 1
   For each NPP piping system of five or more outlets, per outlet ................................................................. 1

Other Inspections and Fees
1. Inspections outside of normal business hours, per hour (minimum charge – 2 hours) ............................................. 1
2. Reinspection fees assessed under provisions of Section 105.2.6, per inspection .................................................. 1
3. Inspections for which no fee is specifically indicated, per hour (minimum charge – ½ hour) .................................... 1
4. Additional plan review required by changes, additions, or revisions to plans or to plans for which an
   initial review has been completed, per hour (minimum charge – ½ hour)......................................................... 1

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 horsepower = 0.746 kW, 1 cubic foot per minute = 0.00047 m³/s

Notes:
1 Jurisdiction will indicate their fees here.
2 This fee shall not apply to an air-handling unit that is a portion of a factory-assembled appliance, cooling unit, evaporative cooler, or absorption unit for which a permit is required elsewhere in this code.
CHAPTER 2
DEFINITIONS

201.0 General.
201.1 Applicability. For the purpose of this code, the following terms have the meanings 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.

203.0 – A –
Absorption Unit. An absorption refrigeration system that has been factory-assembled and tested prior to its installation.

Accepted Engineering Practice. That which conforms to technical or scientific-based principles, test, or standards that are accepted by the engineering profession.

Access Panel. A closure device used to cover an opening into a duct, an enclosure, equipment, or an appurtenance. [NFPA 96:3.3.1]

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 a panel, door, or similar obstruction.

Air, Class 1. Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor. [ASHRAE 62.1:5.16.1]

Air, Class 2. Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors. Class 2 air also includes air that is not necessarily harmful or objectionable, but that is inappropriate for transfer or recirculation to spaces used for different purposes. [ASHRAE 62.1:5.16.1]

Air, Class 3. Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor. [ASHRAE 62.1:5.16.1]

Air, Class 4. Air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered harmful. [ASHRAE 62.1:5.16.1]

Air, Combustion. See Combustion Air.

Air, Conditioned. Air that has been treated to achieve a desired level of temperature, humidity, or cleanliness.

Air, Dilution. Air that enters a draft hood or draft regulator and mixes with the flue gases. [NFPA 54:3.3.2.2]

Air, Exhaust. Air being removed from any space or piece of equipment and conveyed directly to the atmosphere by means of openings or ducts.

Air, Makeup. Air that is provided to replace air being exhausted.

Air, Outside. Air from outside the building intentionally conveyed by openings or ducts to rooms or to conditioning equipment.

Air, Return. Air from the conditioned area that is returned to the conditioning equipment for reconditioning.

Air, Supply. Air being conveyed to a conditioned area through ducts or plenums from a heat exchanger of a heating, cooling, absorption, or evaporative cooling system.

Air Dispersion Systems: Materials intended for use in air handling systems in exposed locations operating under positive pressure.

Air-Handling Unit. A blower or fan used for the purpose of distributing supply air to a room, space, or area.

Air Intakes. An opening in a building’s envelope whose purpose is to allow outside air to be drawn into the structure to replace inside air that is removed by exhaust systems or to improve the quality of the inside air by providing a source of air having a lower concentration of odors, suspended particles, or heating content. [NFPA 96:3.3.2]

Air-Moving System. A system designed to provide heating, cooling, or ventilation in which one or more air-handling units are used to supply air to a common space or are drawing air from a common plenum or space.

Air Pollution Control Devices. Equipment and devices used for the purpose of cleaning air passing through them or by them in such a manner as to reduce or remove the impurities contained therein. [NFPA 96:3.3.3]

Anodeless Riser. An assembly of steel-cased plastic pipe used to make the transition between plastic piping installed underground and metallic piping installed aboveground. [NFPA 54:3.3.4]

Appliance. A device that utilizes an energy source to produce light, heat, power, refrigeration, air conditioning, or compressed fuel gas. This definition also shall include a vented decorative appliance.

Appliance, Fan-Assisted Combustion. An appliance equipped with an integral mechanical means to either draw or force products of combustion through the combustion chamber or heat exchanger. [NFPA 54:3.3.5.4]

Appliance, Low-Heat. A fuel-burning appliance that produces a continuous flue gas temperature, at the point of entrance to the flue, of not more than 1000°F (538°C).
DEFINITIONS

Appliance, Medium-Heat. A fuel-burning appliance that produces a continuous flue gas temperature, at the point of entrance to the flue, of more than 1000°F (538°C) and less than 2000°F (1093°C).

Appliance Categorized Vent Diameter/Area. The minimum vent diameter/area permissible for Category I appliances to maintain a nonpositive vent static pressure where tested in accordance with nationally recognized standards. [NFPA 54:3.3.6]

Appliance Flue Outlet. The opening or openings in a cooking device where vapors, combustion gases, or both leave the cooking device. [NFPA 96:3.3.4] There might or might not be ductwork attached to this opening.

Appliance Fuel Connector. An assembly of listed semi-rigid or flexible tubing and fittings to carry fuel between a fuel-piping outlet and a fuel-burning appliance.

Approved. Acceptable to the Authority Having Jurisdiction.

Approved Testing Agency. An organization primarily established for purposes of testing to approved standards and approved by the Authority Having Jurisdiction.

Appurtenance. An accessory or a subordinate part that enables the primary device to perform or improves its intended function. [NFPA 96:3.3.5]

Assembly Building. A building or a portion of a building used for the gathering together of 50 or more persons for such purposes as deliberation, education, instruction, worship, entertainment, amusement, drinking, dining, or awaiting transportation.

Authority Having Jurisdiction. The organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, installations, or procedures. The Authority Having Jurisdiction shall be a federal, state, local, or other regional department or an individual such as a plumbing official, mechanical official, labor department official, health department official, building official, or others having statutory authority. In the absence of statutory authority, the Authority Having Jurisdiction may be some other responsible party. This definition shall include the Authority Having Jurisdiction’s duly authorized representative.

Automatic. That which provides a function without the necessity of human intervention.

Automatic Boiler. A boiler equipped with certain controls and limit devices.

Azeotrope. A refrigerant blend containing two or more refrigerants whose equilibrium vapor and liquid phase compositions are the same at a given pressure. At this pressure, the slope of the temperature vs. composition curve equals zero, which mathematically is expressed as \( \frac{dT}{d\chi} \bigg|_p = 0 \), which, in turn, implies the occurrence of a maximum, minimum, or saddle point temperature. Azeotropic blends exhibit some segregation of components at other conditions. The extent of the segregation depends on the particular azeotrope and the application. [ASHRAE 34:3]

204.0 – B –

Baffle Plate. An object placed in or near an appliance to change the direction or retard the flow of air, air-fuel mixtures, or flue gases.

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.

Boiler, High-Pressure. A boiler for generating steam at gauge pressures in excess of 15 psi (103 kPa), or for heating water to a temperature in excess of 250°F (121°C) or at a gauge pressure in excess of 160 psi (gauge pressure of 1103 kPa). [NFPA 211:3.3.14.2]

Boiler Room. A room where boilers are installed.

Bonding Conductor or Jumper. A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected. [NFPA 70:100(I)]

Breathing Zone. The region within an occupiable space between planes 3 inches and 72 inches (76 mm and 1829 mm) above the floor and exceeds 2 feet (610 mm) from the walls or fixed air-conditioning equipment. [ASHRAE 62.1:3]

Breathing Zone Outdoor Airflow. The outdoor airflow required in the breathing zone of the occupiable space or spaces in a ventilation zone. [ASHRAE 62.1:6.2.2.1]

Breeching. A metal connector for medium- and high-heat appliances.

Broiler. A general term including broilers, salamanders, barbecues, and other devices cooking primarily by radiated heat, excepting toasters. [NFPA 54:3.3.15]

BTU/H. The listed maximum capacity of any appliance, absorption unit, or burner expressed in British thermal units input per hour, unless otherwise noted.

Building Code. The building code that is adopted by this jurisdiction.

Building Official. See Authority Having Jurisdiction.

Burner, Automatic Boiler. A device to convey fuel into the combustion chamber in proximity to its combustion air supply so as to permit a stable, controlled heat release compatible with the burner design and that is equipped with an ignition system to reliably ignite the entire heat release surface of the burner assembly.

205.0 – C –

CAS Number. The Chemical Abstract System registry number.

Ceiling Radiation Damper. A listed device installed in a ceiling membrane of a fire-resistance-rated floor-ceiling or roof-ceiling assembly to automatically limit the radiative heat transfer through an air inlet/outlet opening. [NFPA 5000:3.3.139.1]

Central Heating Plant or Heating Plant. Environmental heating equipment installed in a manner to supply heat by means of ducts or pipes to areas other than the room or space in which the equipment is located.
Certified. A formally stated recognition and approval of an acceptable level of competency, acceptable to the Authority Having Jurisdiction. [NFPA 96:3.3.10]

Certified Person. A person trained and certified by the equipment manufacturer, or by a recognized organization through a formal certification program for the system to be serviced or cleaned; that is acceptable to the Authority Having Jurisdiction.

Chimney. One or more passageways, vertical or nearly so, for conveying flue or vent gases to the outdoors. [NFPA 54:3.3.18]

Chimney, Factory-Built. A chimney composed of listed factory-built components assembled in accordance with the manufacturer’s installation instructions to form the completed chimney. [NFPA 54:3.3.18.2]

Chimney, Masonry. A field-constructed chimney of solid masonry units, bricks, stones, listed masonry chimney units, or reinforced portland cement concrete, lined with approved suitable chimney flue liners. [NFPA 54:3.3.18.3]

Chimney, Metal. A field-constructed chimney of metal. [NFPA 54:3.3.18.4]

Chimney Classifications:

Chimney, High-Heat Appliance-Type. A factory-built, masonry, or metal chimney suitable for removing the products of combustion from fuel-burning high-heat appliances producing combustion gases in excess of 2000°F (1093°C), measured at the appliance flue outlet.

Chimney, Low-Heat Appliance-Type. A factory-built, masonry, or metal chimney suitable for removing the products of combustion from fuel-burning low-heat appliances producing combustion gases not in excess of 1000°F (538°C) under normal operating conditions, but capable of producing combustion gases of 1400°F (760°C) during intermittent forced firing for periods up to one hour. All temperatures are measured at the appliance flue outlet.

Chimney, Medium-Heat Appliance-Type. A factory-built, masonry, or metal chimney suitable for removing the products of combustion from fuel-burning medium-heat appliances producing combustion gases, not in excess of 2000°F (1093°C), measured at the appliance flue outlet.

Chimney, Residential Appliance-Type. A factory-built or masonry chimney suitable for removing products of combustion from residential-type appliances producing combustion gases not in excess of 1000°F (538°C), measured at the appliance flue outlet. Factory-built Type HT chimneys have high-temperature thermal shock resistance.

Chimney Connector. The pipe that connects a fuel-burning appliance to a chimney. [NFPA 211:3.3.48.1]

Circulators (Circulating Pump). A device that circulates liquids within a closed circuit for an intended purpose.

Classified. See Listed (Third Party Certified).

Clean(ing). For kitchen exhaust systems and cooking equipment, the act of removing grease, oil deposits, and other residue. [NFPA 96:3.3.12]

Clearly Identified. Capable of being recognized by a person of normal vision without causing uncertainty and indecisiveness about the location or operating process of the identified item. [NFPA 96:3.3.13]

Closed Combustible Construction. Combustible building construction, including walls, structural framing, roofs, floor ceilings, and floor-ceiling assemblies, continuously enclosing a grease duct on four sides where one or more sides require protection in accordance with Section 507.4.

Closed Combustion Solid-Fuel-Burning Appliance. A heat-producing appliance that employs a combustion chamber that has no openings other than the flue collar, fuel-charging door, and adjustable openings provided to control the amount of combustion air that enters the combustion chamber.

Closet. See Confined Space.

Clothes Dryer. An appliance used to dry wet laundry by means of heat. [NFPA 54:3.3.19]

Clothes Dryer, Type 1. Primarily used in family living environment. May or may not be coin-operated for public use. [NFPA 54:3.3.19.1]

Clothes Dryer, Type 2. Used in business with direct intercourse of the function with the public. May or may not be operated by public or hired attendant. May or may not be coin-operated. [NFPA 54:3.3.19.2]

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.

Combination Fire and Smoke Damper. A device that meets both the fire damper and smoke damper requirements. [NFPA 5000:3.3.139.2]

Combustible Material. A material that, in the form in which it is used and under the conditions anticipated, will ignite and burn; a material that does not meet the definition of noncombustible. [NFPA 54:3.3.64.1]

Combustion Air. The total amount of air provided to the space that contains fuel-burning equipment. Includes air for fuel combustion, draft hood dilution, and ventilation of the equipment enclosure.

Combustion Chamber. The portion of an appliance within which combustion occurs. [NFPA 54:3.3.21]

Commercial Food Heat-Processing Equipment. Equipment used in a food establishment for heat-processing food or utensils and that produces grease vapors, steam, fumes, smoke, or odors that are required to be removed through a local exhaust ventilation system.

Compensating Hood. A hood for commercial food heat-processing equipment that has an outside-air supply with air.
delivered below or within the hood. Where makeup air is diffused directly into the exhaust within the hood cavity, it becomes a short-circuit hood.

**Compressor, Positive Displacement.** A compressor in which increase in pressure is attained by changing the internal volume of the compression chamber.

**Compressor, Refrigerant.** A machine, with or without accessories, for compressing a refrigerant vapor.

**Concealed Spaces.** That portion(s) of a building behind walls, over suspended ceilings, in pipe chases, attics, and elsewhere whose size might normally range from 1 1/2 inch (44 mm) stud spaces to 8 foot (2438 mm) interstitial truss spaces and that might contain combustible materials such as building structural members, thermal, electrical insulation, or both, and ducting. Such spaces have sometimes been used as HVAC plenum chambers.

**Condensate.** The liquid phase produced by condensation of a particular gas or vapor.

**Condenser.** The part of the system designed to liquefy refrigerant vapor by removal of heat.

**Condensing Appliance.** An appliance that condenses part of the water vapor generated by the burning of hydrogen in fuels.

**Condensing Unit.** A mechanical refrigeration system, consisting of one or more power-driven compressors, condensers, liquid receivers where provided, and the regularly furnished accessories that have been factory assembled and tested prior to its installation.

**Conditioned Space.** An area, room, or space normally occupied and being heated or cooled for human habitation comfort by any equipment.

**Confined Space.** A room or space having a volume less than 50 cubic feet per 1000 British thermal units per hour (Btu/h) (4.83 m³/kW) of the aggregate input rating of all fuel-burning appliances installed in that space.

**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.

**Continuous Enclosure.** A recognized architectural or mechanical component of a building having a fire resistance rating as required for the structure and whose purpose is to enclose the vapor removal duct for its full length to its termination point outside the structure without any portion of the enclosure having a fire resistance rating less than the required value. [NFPA 96:3.3.22.1]

**Continuous Pilot.** A pilot that burns without turndown throughout the entire period that the boiler is in service, whether or not the main burner is firing.

**Continuous Weld.** A metal-joining method that produces a product without visible interruption or variation in quality. [NFPA 96:3.3.15] For the purpose of the definition, it specifically includes the exhaust compartment of hoods and welded joints of exhaust ducts, yet specifically does not include filter support frames or appendages inside hoods.

**Conversion Burner, Gas.** A unit consisting of a burner and its controls utilizing gaseous fuel for installation in an appliance originally utilizing another fuel. [NFPA 54:3.3.17.2]

**Cooling.** Air cooling to provide a room or space temperature of 68°F (20°C) or above.

**Cooling System.** All of the equipment, ducts and components, including associated refrigeration, intended or installed for the purpose of cooling air by mechanical means and discharging such air into any room or conditioned space. This definition shall not include an evaporative cooler.

**Cooling Unit.** A self-contained refrigeration system that has been factory assembled tested, and installed with or without conditioned air and ducts, without connecting any refrigerant-containing parts. This definition shall not include a portable cooling unit or an absorption unit.

**Copper Alloy.** A homogenous mixture of two or more metals in which copper is the primary component, such as brass and bronze.

**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.

**CSST.** An acronym for corrugated stainless steel tubing.

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206.0 – D –

**Damper.** A valve or plate for controlling draft or the flow of gases, including air. [NFPA 211:3.3.52]

**Combination Fire-Smoke Damper.** An automatic-closing metal assembly consisting of one or more louvers, blades, slats, or vanes that closes upon detection of heat or smoke as to restrict the passage of heat and smoke.

**Fire Damper.** An automatic-closing metal assembly consisting of one or more louvers, blades, slats, or vanes that closes upon detection of heat so as to restrict the passage of flame and is listed to the applicable recognized standards.

**Smoke Damper.** A damper arranged to seal off airflow automatically through a part of an air duct system so as to restrict the passage of smoke and is listed to the applicable recognized standard.

**Volume Damper.** A device that, when installed, will restrict, retard, or direct the flow of air in any duct, or the products of combustion in any heat-producing equipment, its vent connector, vent, or chimney.

**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 is the elevation of the highest existing grade of the building’s perimeter plus the depth number (in feet) 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 is taken as being equal to 2 feet (610 mm).

**Detection Devices.** Electrical, pneumatic, thermal, mechanical, or optical sensing instruments, or subcomponents of such instruments, whose purpose is to cause an automatic action upon the occurrence of some preselected event. [NFPA...
96:3.3.17] In the context of this document, the event in question could be excessive temperature or flame, and the action could be the operation of a fire-extinguishing system.

**Dips.** Depression or cup like places in horizontal duct runs in which liquids could accumulate.

**Direct Gas-Fired Nonrecirculating Industrial Air Heater.** A nonrecirculating industrial air heater in which all the products of combustion generated by the appliance are released into the outdoor airstream being heated. [NFPA 54:3.3.56.1]

**Direct Gas-Fired Recirculating Industrial Air Heater.** An air recirculating heater in which all of the products of combustion generated by the appliance are released into the airstream being heated. [NFPA 54:3.3.56.2]

**Direct-Vent Appliances.** Appliances that are constructed and installed so that all air for combustion is derived directly from the outdoors and all flue gases are discharged to the outdoors. [NFPA 54:3.3.5.3]

**Discharge.** The final portion of a duct or pipe where the product being conveyed is emptied or released from confinement; the termination point of the pipe or duct. [NFPA 96:3.3.18]

**Discrete Products in Plenums.** Individual, distinct products which are non-continuous such as pipe hangers, duct registers, duct fittings, and duct straps.

**District Heating Plant.** A power boiler plant designed to distribute hot water or steam to users located off the premises.

**Draft Hood.** A nonadjustable device built into an appliance, or made a part of the vent connector from an appliance, that is designed to:

1. Provide for the ready escape of the flue gases from the appliance in the event of no draft, backdraft, or stoppage beyond the draft hood.
2. Prevent a backdraft from entering the appliance.
3. Neutralize the effect of stack action of the chimney or gas vent upon the operation of the appliance. [NFPA 54:3.3.31]

**Duct.** A tube or conduit for transmission of air, fumes, vapors, or dust. 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.

**Duct Furnace.** A furnace normally installed in distribution ducts of air-conditioning systems to supply warm air for heating. This definition applies only to an appliance that, for air circulation, depends on a blower not furnished as part of the furnace. [NFPA 54:3.3.45.3]

**Duct System.** A continuous passageway for the transmission of air and vapors that, in addition to the containment components themselves, might include duct fittings, dampers, plenums, other items, and air-handling equipment. [NFPA 96:3.3.20]

**Ductless Mini-Split System.** A heating and cooling equipment that includes one or multiple indoor evaporator, air handler, or both units, an outdoor condensing unit that is connected by refrigerant piping, and electrical wiring. A ductless mini-split system is capable of cooling or heating one or more rooms without the use of traditional ductwork.

**Dwelling.** A building or portion thereof that contains not more than two dwelling units.

**Dwelling Unit.** A building or portion thereof that contains living facilities, including provisions for sleeping, eating, cooking, and sanitation, as required by this code, for not more than one family.

**2070 – E –**

**Easily Accessible.** See Accessible, Readily.

**Effective Ground-Fault Current Path.** An intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground-fault detectors on high-impedance grounded systems. [NFPA 54:3.3.34]

**Electric Duct Heaters.** A heater located in the airstream of a forced-air system where the air-moving unit is not provided as an integral part of the equipment.

**Electric Heating Appliance.** A device that produces heat energy to create a warm environment by the application of electric power to resistance elements, refrigerant compressors, or dissimilar material junctions.

**Electrical Code.** The National Electrical Code promulgated by the National Fire Protection Association, as adopted by this jurisdiction.

**Emergency Alarm System.** A system intended to provide the indication, notification and warning of abnormal conditions and summon appropriate aid.

**Emergency Control Station.** An approved location on the premises where signals from emergency equipment are received.

**Environmental Air Duct.** Ducting used for conveying air at temperatures not exceeding 250°F (121°C) to or from occupied areas of any occupancy through other than heating or air-conditioning systems, such as ventilation for human usage, domestic kitchen range exhaust, bathroom exhaust ducts, and domestic-type clothes dryer exhaust ducts.

**Equipment.** A general term including materials, fittings, devices, appliances, and apparatus used as part of or in connection with installations regulated by this code.

**Evaporative Cooler.** A device used for reducing the sensible heat of air for cooling by the process of evaporation of water into an airstream.

**Evaporative Cooling System.** Equipment intended or installed for the purpose of environmental cooling by an evaporative cooler from which the conditioned air is distributed through ducts or plenums to the conditioned area.

**Evaporator.** Part of a refrigeration system in which liquid refrigerant is vaporized to produce refrigeration.
**Excess Flow Valve (EFV).** A valve designed to activate when the fuel gas passing through it exceeds a prescribed flow rate. [NFPA 54:3.3.99.3]

**Fabrication Area (Fab Area).** An area within a Group H Occupancy semiconductor fabrication facility and related research and development areas in that there are processes involving hazardous production materials. Such areas are allowed to include ancillary rooms or areas such as dressing rooms and offices that are directly related to the fab area processes.

**Factory-Built Grease Duct Enclosures.** A listed factory-built grease duct system evaluated as an enclosure system for reduced clearances to combustibles and as an alternative to a duct with its fire-rated enclosure. [NFPA 96:3.3.22.2.1]

**Field-Applied Grease Duct Enclosures.** A listed system evaluated for reduced clearances to combustibles and as an alternative to a duct with its fire-rated enclosure. [NFPA 96:3.3.22.2.2]

**Fire Code.** The fire code adopted by this jurisdiction.

**Fire Partition.** An interior wall or partition of a building that separates two areas and serves to restrict the spread of fire but does not qualify as a fire wall.

**Fire Resistance Rating.** The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with ASTM E119 or UL 263.

**Fire-Resistive Construction.** Construction in accordance with the requirements of the building code for the time period specified.

**Fire Wall.** A wall separating buildings or subdividing a building to prevent the spread of the fire and having a fire resistance rating and structural stability. [NFPA 96:3.3.26]

**Fireplace Stove.** A chimney-connected, solid-fuel-burning stove (appliance) having part of its fire chamber open to the room.

**Flammable Vapor or Fumes.** The concentration of flammable constituents in air that exceeds 25 percent of its Lower Flammability Limit (LFL).

**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.

**Floor Furnace.** A completely self-contained unit furnace suspended from the floor of the space being heated, taking air for combustion from outside this space. [NFPA 54:3.3.45.5] With means for observing flames and lighting the appliance from such space.

**Forced-Air Furnace.** A furnace equipped with a fan or blower that provides the primary means for circulation of air. [NFPA 54:3.3.45.6]

**Downflow-Type Furnace.** A forced-air-type furnace designed with airflow essentially in a vertical path, discharging air at or near the bottom of the furnace. [NFPA 211:3.3.79.2]

**Enclosed Furnace.** A specific heating or heating and ventilating furnace incorporating an integral total enclosure and using only outside air for combustion.

**Horizontal-Type Furnace.** A forced-air-type furnace designed with airflow through the furnace, essentially in a horizontal path. [NFPA 211:3.3.79.3]

**Upflow-Type Furnace.** A forced-air-type furnace designed with airflow essentially in a vertical path, discharging air at or near the top of the furnace. [NFPA 211:3.3.79.5]

**Fractionation.** A change in composition of a blend by preferential evaporation of the more volatile component or condensation of the less volatile component.

**Fuel Gas.** Natural, manufactured, liquefied petroleum, or a mixture of these.

**Fume Incinerators.** Devices utilizing intense heat or fire to break down, oxidize, or both vapors and odors contained in gases or air being exhausted into the atmosphere. [NFPA 96:3.3.27]

**Furnace, Central.** A self-contained appliance for heating air by transfer of heat of combustion through metal to the air and designed to supply heated air through ducts to spaces remote from or adjacent to the appliance location. [NFPA 54:3.3.45.1]

**Fusible Link.** A form of fixed-temperature heat-detecting device sometimes employed to restrain the operation of an electrical or mechanical control until its designed temperature is reached. [NFPA 96:3.3.28] Such devices are to be replaced following each operation.

**Fusible Plug.** A device arranged to relieve pressure by operation of a fusible member at a predetermined temperature.

**Galvanized Steel.** A steel that has been coated with a thin layer of zinc for corrosion protection.

**Gas Convenience Outlet.** A permanently mounted, hand-operated device providing a means for connecting and disconnecting an appliance or an appliance connector to the gas supply piping. The device includes an integral, manually operated gas valve with a nondisplaceable valve member so that disconnection can be accomplished only where the manually operated gas valve is in the closed position. [NFPA 54:3.3.48]

**Gas Piping.** An installation of pipe, valves, or fittings that are used to convey fuel gas, installed on any premises or in a building, but shall not include:

1. A portion of the service piping.
2. An approved piping connection 6 feet (1829 mm) or less in length between an existing gas outlet and a gas appliance in the same room with the outlet.

**Gas Piping System.** An arrangement of gas piping or regulators after the point of delivery and each arrangement of gas piping serving a building, structure, or premises, whether individually metered or not.

**Generator.** A device equipped with a means of heating used in an absorption system to drive refrigerant out of solution.
Gravity Heating System. A heating system consisting of a gravity-type warm air furnace, together with all air ducts or pipes and accessory apparatus installed in connection therewith.

Gravity-Type Floor Furnace. A floor furnace depending primarily on circulation of air by gravity. This classification also includes floor furnaces equipped with booster-type fans that do not materially restrict free circulation of air by gravity flow when such fans are not in operation. [NFPA 211:3.3.79.12.2]

Grease. Rendered animal fat, vegetable shortening, and other such oily matter used for the purposes of and resulting from cooking, preparing foods, or both. [NFPA 96:3.3.29] Grease might be liberated and entrained with exhaust air or might be visible as a liquid or solid.

Grease Ducts. A containment system for the transportation of air and grease vapors that is designed and installed to reduce the possibility of the accumulation of combustible condensation and the occurrence of damage if a fire occurs within the system. [NFPA 96:3.3.20.2]

Grease Filter. A removable component of the grease removal system designed to capture grease and direct it to a safe collection point. [NFPA 96:3.3.24.1]

Grease Filter, Mesh-Type. A filter construction consisting of a net made from intersecting strands with a space between each strand. [NFPA 96:3.3.24.2]

Grease Removal Devices. A system of components designed and intended to process vapors, gases, or air as it is drawn through such devices by collecting the airborne grease particles and concentrating them for further action at some future time, leaving the exiting air with a lower amount of combustible matter.

Greasetight. Constructed and performing in such a manner as not to permit the passage of grease under normal cooking conditions. [NFPA 96:3.3.31]

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, such as geothermal heat pumps (GHP), geo-exchange, and ground-source (GS) systems and are used to meet a variety of marketing or institutional needs.

Grounding Electrode. A conducting object through which a direct connection to earth is established. [NFPA 70:100(1)]

Heat Pump. A refrigeration system that extracts heat from one substance and transfers it to another portion of the same substance or to a second substance at a higher temperature for a beneficial purpose.

Heat (Energy) Recovery Ventilator. A device intended to remove air from buildings, replace it with outside air, and in the process transfer heat from the warmer to the colder airstreams.

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 is 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.

Heating System. A warm air heating plant consisting of a heat exchanger enclosed in a casing, from which the heated air is distributed through ducts to various rooms and areas. A heating system includes the outside air, return air, and supply air system, and all accessory apparatus and equipment installed in connection therewith.

High Limit Control Device. An operating device installed and serving as an integral component of a deep-fat fryer that provides secondary limitation of the grease temperature by automatically disconnecting the thermal energy input when the temperature limit is exceeded. [NFPA 96:3.3.32]

High Purity Piping. A form of process piping but is usually specified for critical clean applications in the semiconductor, pharmaceutical, biotechnology, chemical, fiber optics, food, and dairy industries.

Highside. The parts of a refrigeration system subjected to approximately condenser pressure.

Hood. An air-intake device connected to a mechanical exhaust system for collecting and removing grease-laden vapors, fumes, smoke, steam, heat, or odors from commercial food heat-processing equipment.

Fixed Baffle. A listed unitary exhaust hood design where the grease removal device is a nonremovable assembly that contains an integral fire-activated water-wash fire-extinguishing system listed for this purpose. [NFPA 96:3.3.33.1]

Type I. A kitchen hood for collecting and removing grease and smoke.

Type II. A general kitchen hood for collecting and removing steam, vapor, heat, or odors.

Hot-Water-Heating Boiler. A boiler having a volume exceeding 120 gallons (454 L), a heat input exceeding 200,000 Btu/h (58.6 kW), or an operating temperature exceeding 210°F (99°C) that provides hot water to be used externally to itself.
DEFINITIONS

HPM Storage Room. A room used for the storage or dispensing of hazardous production material (HPM) and that is classified as a Group H, Division 1, or Division 2, Division 3, or Division 4 Occupancy.

Hydronics. Of or relating to a heating or cooling system that transfers energy by circulating a fluid through a system of pipes or tubing.

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

211.0 – I –

IDLH (Immediately Dangerous to Life and Health). A concentration of airborne contaminant’s, normally expressed in parts per million (ppm) or milligrams per cubic meter (mg/m³), that represents the maximum level from which one is capable of escaping within 30 minutes without escape-imparing symptoms or irreversible health effects. This level is established by the National Institute of Occupational Safety and Health (NIOSH).

Incinerator. An appliance or combustion chamber for the reduction, by burning, of rubbish, garbage, and other wastes. [NFPA 211:3.3.91]

Industrial Heating Equipment. Includes appliances, devices, or equipment used, or intended to be used, in an industrial, manufacturing, or commercial occupancy for applying heat to any material being processed, but shall not include water heaters, boilers, or portable equipment used by artisans in pursuit of a trade.

Insanitary Location. An area, space, or room where the air is unfit or undesirable for circulation to occupiable parts of a building.

Interconnected. Mutually assembled to another component in such a manner that the operation of one directly affects the other or that the contents of one specific duct system are allowed to encounter or contact the products being moved by another duct system. [NFPA 96:3.3.34]

Interlock. A device that senses a limit or off-limit condition or improper sequence of events and shuts down the offending or related piece of equipment or prevents proceeding in an improper sequence in order to prevent a hazardous condition from developing.

Intermittent Pilot. A pilot that burns during light-off and while the main burner is firing, and that is shut off with the main burner.

Interrupted Pilot. A pilot that burns during light-off and that is shut off during normal operation of the main burner.

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 being 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, Flared. 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, Mechanical. General form for gastight or liquid-tight joints obtained by the joining of parts through a positive holding mechanical construction.

Joint, Press-Connect. A permanent mechanical joint consisting of an elastomeric seal or an elastomeric seal and corrosion-resistant grip ring. The joint is made with a pressing tool and jaw or ring approved by the fitting manufacturer.

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).

LEL (Lower Explosive Limit). See LFL.

LFL (Lower Flammable Limit or Lower Limit of Flammability). The minimum concentration of a substance that propagates a flame through a homogeneous mixture of the substance and air under the specified test conditions. The LFL is sometimes referred to as LEL (Lower Explosive Limit). For the purposes of this definition, LFL and LEL are identical.

Limited-Combustible Material. Refers to a building construction material that does not comply with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 British thermal units per pound-force (Btu/lb) (8141 kJ/kg), where tested in accordance with NFPA 259, and includes either of the following:

1. Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 of an inch (3.2 mm), that has a flame-spread index not greater than 50.

2. Materials, in the form and thickness used, having neither a flame-spread index greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame-spread index greater than 25 nor evidence of continued progressive combustion, where tested in accordance with ASTM E84.
Line Contact Installation. An installation in which a furnace is installed so that building joists, studs, or framing are contacted by the furnace jacket upon the lines formed by the intersection of the jacket sides with the top surface.

Lineset. A set of two refrigerant pipes that extends from the condenser to the evaporator (cooling coil) in direct systems, consisting of a suction line and a liquid line.

Liquefied Petroleum Gas (LP-Gas). Means and includes a material composed predominantly of any of the following hydrocarbons or mixtures of them: propane, propylene, butanes (normal butane or isobutane), and butylenes. When reference is made to liquefied petroleum gas in this code, it shall refer to liquefied petroleum gases in either the liquid or gaseous state.

Liquefied Petroleum Gas (LP-Gas) Facilities. Liquefied petroleum gas (LP-Gas) facilities include tanks, containers, container valves, regulating equipment, meters, appurtenances, or any combination thereof for the storage and supply of liquefied petroleum gas for a building, structure, or premises.

Liquid-Tight. Constructed and performing in such a manner as not to permit the passage of liquid at any temperature. [NFPA 96:3.3.35]

Listed (Third Party Certified). Equipment or materials included in a list published by a listing agency (accredited conformity assessment body) that maintains periodic inspection of current production of listed equipment or materials 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 are accepted by the Authority Having Jurisdiction, which is in the business of listing or 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 specified manner.

Low-Pressure Hot-Water-Heating Boiler. A boiler furnishing hot water at pressures not exceeding 160 psi (1103 kPa) and at temperatures not exceeding 250°F (121°C).

Low-Pressure Steam-Heating Boiler. A boiler furnishing steam at pressures not exceeding 15 psi (103 kPa).

Low-Probability Pump. A pump that (a) is permanently sealed to prevent atmospheric release of the pumped fluid, (b) incorporates a static seal to prevent atmospheric release of the pumped fluid, or (c) incorporates not less than two sequential dynamic shaft seals and automatically shuts down upon failure of any seal to prevent atmospheric release of the pumped fluid. [ASHRAE 15:3]

Lowside. Refers to the parts of a refrigeration system subjected to approximate evaporator pressure.

215.0 – M –

Machinery. The refrigeration equipment forming a part of the refrigeration system, including, but not limited to, the following: compressors, condensers, liquid receivers, evaporators, and connecting piping.

Mechanical Ventilation. Ventilation provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows. [ASHRAE 62.1:3]

Miniature Boiler. A power boiler having an internal shell diameter of 16 inches (406 mm) or less, a gross volume of 5 cubic feet (0.14 m³) or less, a heating surface of 20 square feet (1.86 m²) or less (not applicable to electric boilers), and not exceeding 100 psi (689 kPa).

216.0 – N –

Natural Ventilation. Ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building. [ASHRAE 62.1:3]

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 item 1 above, with a surfaced material not over ¼ 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 item 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.

Nonhazardous Process Piping (NPP). Production material piping or tubing conveying a liquid or gas that is not classified as hazardous production material piping.

217.0 – O –

Occupancy. The purpose for which a building or part thereof is used or intended to be used.

Occupancy Classification. Classifications are defined in the building code.

Occupational Exposure Limit (OEL). The time-weighted average (TWA) concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers can be repeatedly exposed without adverse effect, based on the OSHA PEL, ACGIH TLV-TWA, TERA OARS-WEEL, or consistent value. [ASHRAE 34:3]

Occupiable Space. An enclosed space intended for human activities excluding those spaces intended primarily for other
purposes such as storage rooms and equipment rooms that are only occupied occasionally and for short periods of time. [ASHRAE 62.1:3]

**Open Combustible Construction.** Combustible building construction, including wall, structural framing, roof, roof ceiling, floor, and floor-ceiling assemblies, adjacent to a grease duct on three or fewer sides where one or more sides require protection in accordance with Section 507.4.

**218.0 – P –**

**Package Boiler.** A class of boiler defined herein and shall be a boiler equipped and shipped complete with fuel-burning equipment, automatic controls and accessories, and mechanical draft equipment.

**PE.** Polyethylene.

**PE-AL-PE.** Polyethylene-aluminum-polyethylene.

**PE-RT.** Polyethylene of raised temperature.

**PEL (Permissible Exposure Limit).** The time-weighted average concentration [set by the U.S. Occupational Safety and Health Administration (OSHA)] for a normal 8-hour workday and a 40-hour workweek to which nearly all workers can be repeatedly exposed without adverse effect. Chemical manufacturers publish similar recommendations [e.g., acceptable exposure level (AEL), industrial exposure limit (IEL), or occupational exposure limit (OEL), depending on the company], generally for substances for which PEL has not been established. [ASHRAE 34:3] The maximum permitted time-weighted average exposures to be utilized are those published in 29 CFR 1910.1000.

**PEX.** Cross-linked polyethylene.

**PEX-AL-PEX.** Cross-linked polyethylene-aluminum-cross-linked polyethylene.

**Pilot.** A burner smaller than the main burner that is ignited by a spark or other independent and stable ignition source, and that provides ignition energy required to immediately light off the main burner.

**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.

**Pitched.** To be fixed or set at a desired angle or inclination. [NFPA 96:3.3.39]

**Plenum.** An air compartment or chamber including unoccupied crawl space areas above a ceiling or below a floor, including air spaces below raised floors of computer/data processing centers or attic spaces, to one or more ducts are connected and that forms part of either the supply-air, return-air, or exhaust-air system, other than the occupiable space being conditioned.

**Plumbing Code.** The Uniform Plumbing Code promulgated by the International Association of Plumbing and Mechanical Officials, as adopted by this jurisdiction.

**Portable Cooling Unit.** A self-contained refrigerating system, not over 3 horsepower (hp) (2.2 kW) rating that has been factory assembled and tested, installed without supply-air ducts and without connecting any refrigerant-containing parts. This definition shall not include an absorption unit.

**Portable Evaporative Cooler.** An evaporative cooler that discharges the conditioned air directly into the conditioned area without the use of ducts and can be readily transported from place to place without dismantling any portion thereof.

**Portable Heating Appliance.** A heating appliance designed for environmental heating that may have a self-contained fuel supply and is not secured or attached to a building by any means other than by a factory-installed power supply cord.

**Portable Ventilating Equipment.** Ventilating equipment that can be readily transported from place to place without dismantling a portion thereof and that is not connected to a duct.

**Power Boiler.** A boiler in which steam is generated at pressures exceeding 15 psi (103 kPa).

**Power Boiler Plant.** One or more power steam boilers or power hot water boilers and connecting piping and vessels within the same premises.

**Power Hot Water Boiler (High Temperature Water Boiler).** A boiler used for heating water or liquid to a pressure exceeding 160 psi (1103 kPa) or to a temperature exceeding 250°F (121°C).

**PP.** Polypropylene.

**Pressure, Design.** The maximum working pressure for which a specific part of a refrigeration system is designed.

**Pressure, Field Test.** A test performed in the field to prove system tightness.

**Pressure-Imposing Element.** A device or portion of the equipment used for the purpose of increasing the pressure of the refrigerant vapor.

**Pressure-Limiting Device.** A pressure-responsive mechanism designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

**Pressure-Relief Device.** A pressure-actuated valve or rupture member or fusible plug designed to automatically relieve excessive pressure.

**Pressure Test.** The minimum gauge pressure to which a specific system component is subjected under test condition.

**Pressure Vessel (Unfired).** A closed container, having a nominal internal diameter exceeding 6 inches (152 mm) and a volume exceeding 1½ cubic feet (0.04 m³), for liquids, gases, vapors subjected to pressures exceeding 15 psi (103 kPa), or steam under a pressure.

**Pressure Vessel, Refrigerant.** A refrigerant-containing receptacle that is a portion of a refrigeration system, but shall not include evaporators, headers, or piping of certain limited size and capacity.

**Process Piping.** Piping or tubing that conveys liquid or gas, which is used directly in research, laboratory, or production processes.
**Product-Conveying Duct.** Ducting used for conveying solid particulates, such as refuse, dust, fumes, and smoke; liquid particulate matter, such as spray residue, mists, and fogs; vapors, such as vapors from flammable or corrosive liquids; noxious and toxic gases; and air at temperatures exceeding 250°F (121°C).

**Purge.** The acceptable method of scavenging the combustion chamber, boiler passes, and breeching to remove combustible gases.

**PVC.** Polyvinyl chloride.

**219.0 – Q – Qualified.** A competent and capable person or company that has met the requirements and training for a given field acceptable to the Authority Having Jurisdiction.

**Quick-Disconnect Device, Fuel Gas.** A hand-operated device that provides a means for connecting and disconnecting an appliance or an appliance connector to a gas supply and that is equipped with an automatic means to shut off the gas supply when the device is disconnected. [NFPA 54:3.3.28.3]

**220.0 – R – Radiant Room Heater.** A room heater designed to transfer heat primarily by direct radiation. [NFPA 211:3.3.88.2.2]

**Receiver, Liquid.** A vessel permanently connected to a refrigeration system by inlet and outlet pipes for storage of liquid.

**Recirculating Systems.** Systems for control of smoke or grease-laden vapors from commercial cooking equipment that do not exhaust to the outside. [NFPA 96:3.3.41]

**Reclaimed Refrigerants.** Refrigerants reprocessed to the same specifications as new refrigerants by any means, including distillation. Such refrigerants have been chemically analyzed to verify that those specifications have been met. [ASHRAE 15:3]

**Recovered Refrigerants.** Refrigerants removed from a system in any condition without necessarily testing or processing them. [ASHRAE 15:3]

**Recycled Refrigerants.** Refrigerants for which contaminants have been reduced by oil separation, removal of non-condensable gases, and single or multiple passes through filter driers or other devices that reduce moisture, acidity, and particulate matter. [ASHRAE 15:3]

**Refrigerant Designation.** The unique identifying alphanumeric value assigned to an individual refrigerant.

**Refrigerant Safety Classifications.** Made up of a letter (A or B), that indicates the toxicity class, followed by a number (1, 2, or 3), that indicates the flammability class. Refrigerant blends are similarly classified, based on the compositions at their worst cases of fractionation, as separately determined for toxicity and flammability. In some cases, the worst case of fractionation is the original formulation.

**Flammability Classification.** Refrigerants shall be classified for flammability in accordance with one of the following:

**Class 1.** Refrigerants that do not show flame propagation where tested in air at 14.7 pound-force per square inch absolute (psia) (101 kPa) and 140°F (60°C).

**Class 2.** Refrigerants having a lower flammability limit (LFL) of more than 0.00625 pound per cubic foot (lb/ft³) (0.10012 kg/m³) at 140°F (60°C), 14.7 psia (101 kPa), and a heat of combustion of less than 8169 British thermal units per pound (Btu/lb) (1.8988 E+07 J/kg).

**Class 3.** Refrigerants that are highly flammable having a LFL of not more than 0.00625 lb/ft³ (0.10012 kg/m³) at 140°F (60°C) and 14.7 psia (101 kPa) or a heat of combustion not less than 8169 Btu/lb (1.8988 E+07 J/kg).

**Toxicity Classification.** Refrigerants shall be classified for the toxicity in accordance with one of the following:

**Class A.** Refrigerants have an occupational exposure limit (OEL) of not less than 400 parts per million (ppm).

**Class B.** Refrigerants have an OEL of less than 400 ppm.

**Refrigeration Machinery Room.** A room designed to house compressors and refrigerant pressure vessels.

**Refrigeration Room or Space.** A room or space in which an evaporator or brine coil is located for the purpose of reducing or controlling the temperature within the room or space to less than 68°F (20°C).

**Refrigeration System, Absorption.** A heat-operated closed refrigeration cycle in which a secondary fluid, the absorbent, absorbs a primary fluid, the refrigerant that has been vaporized in the evaporator.

**Refrigeration System, Direct.** A system in which the evaporator or condenser of the refrigerating system is in direct contact with the air or other substances to be cooled or heated. [ASHRAE 15:5.1.1]

**Refrigeration System, Indirect.** A system in which a secondary coolant cooled or heated by the refrigeration system is circulated to the air or other substance to be cooled or heated. Indirect systems are distinguished by the method of application given below. [ASHRAE 15:5.1.2]

**Indirect Open Spray System.** A system in which a secondary coolant is in direct contact with the air or other substance to be cooled or heated. [ASHRAE 15:5.1.2.1]

**Double Indirect Open Spray System.** A system in which the secondary substance for an indirect open spray system is heated or cooled by the secondary coolant circulated from a second enclosure. [ASHRAE 15:5.1.2.2]

**Indirect Closed System.** A system in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated. [ASHRAE 15:5.1.2.3]

**Refrigeration System, Mechanical.** A combination of interconnected refrigerant-containing parts constituting one closed refrigerant circuit in which a refrigerant is circulated for the purpose of extracting heat and in which a compressor is used for compressing the refrigerant vapor.
**DEFINITIONS**

**Refrigeration System, Self-Contained.** A complete factory-assembled and tested system that is shipped in one or more sections and has no refrigerant-containing parts that are joined in the field by other than companion or block valves.

**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.

**Removable.** Capable of being transferred to another location with a limited application of effort and tools. [NFPA 96:3.3.42]

**Replacement Air.** See Air, Makeup.

**Residential Building.** A building or portion thereof designed or used for human habitation.

**Riser Heat Pipe.** A duct that extends at an angle of 45 degrees (0.79 rad) from the horizontal. This definition shall not include any boot connection.

**Room Heater.** A freestanding, nonrecessed, environmental heating appliance installed in the space being heated and not connected to ducts.

**Room Heater, Unvented.** An unvented, self-contained, freestanding, nonrecessed, fuel-gas-burning appliance for furnishing warm air by gravity or fan circulation to the space in which installed, directly from the heater without duct connection. [NFPA 54:3.3.56.6]

**Rupture Member.** A pressure-relief device that operates by the rupture of a diaphragm within the device on a rise to a predetermined pressure.

**221.0 – S –**

**Seam, Welded.** See Joint, Welded.

**Secondary Filtration.** Fume incinerators, thermal recovery units, air pollution control devices or other filtration media installed in ducts or hoods located in the path of travel of exhaust products after the initial filtration.

**Self-Contained.** Having all essential working parts, except energy and control connections, so contained in a case or framework that they do not depend on appliances or fastenings outside of the machine.

**Service Corridor.** A fully enclosed passage used for transporting hazardous production materials and purposes other than required exiting.

**Service Piping.** The piping and equipment between the street gas main and the gas piping system inlet that is installed by, and is under the control and maintenance of, the serving gas supplier.

**Shaft.** An interior space enclosed by walls or construction extending through one or more stories or basements that connect openings in successive floors, or floors and roof, to accommodate elevators, dumbwaiters, mechanical equipment, or similar devices to transmit light or ventilation air.

**Shaft Enclosure.** The walls or construction forming the boundaries of a shaft.

**Shall.** Indicates a mandatory requirement.

**Should.** Indicates a recommendation or that which is advised but not required.

**Single Hazard Area.** Where two or more hazards can be simultaneously involved in fire by reason of their proximity, as determined by the Authority Having Jurisdiction. [NFPA 96:3.3.44]

**Smoke Detector.** An approved device that senses visible or invisible particles of combustion.

**Solid Cooking Fuel.** A solid, organic, consumable fuel such as briquettes, mesquite, hardwood, or charcoal. [NFPA 96:3.3.45]

**Solid-Fuel Cooking Equipment.** Cooking equipment that utilizes solid fuel. [NFPA 96:3.3.23.2] This equipment includes ovens, tandoor charcoal pots, grills, broilers, rotisseries, barbecue pits, or other type of cooking equipment that derives all or part of its heat source from the burning of solid cooking fuel.

**Solvent.** A substance (usually liquid) capable of dissolving or dispersing another substance; a chemical compound designed and used to convert solidified grease into a liquid or semiliquid state in order to facilitate a cleaning operation. [NFPA 96:3.3.46]

**Spark Arrester.** A device or method that minimizes the passage of airborne sparks and embers into a plenum, duct, and flue. [NFPA 96:3.3.48]

**Standard.** A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that 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.

**Stationary Fuel Cell Power Plant.** A self-contained package or factory-matched packages that constitute an automatically operated assembly of integrated systems for generating useful electrical energy and recoverable energy that is permanently connected and fixed in place.

**Steam-Heating Boiler.** A boiler operated at pressures not exceeding 15 psi (103 kPa) for steam.

**Strength, Ultimate.** The highest stress level that the component can tolerate without rupture.

**System Outdoor Airflow.** The rate of outdoor airflow required at the ventilation system outdoor air intake.

**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 Recovery Unit.** A device or series of devices whose purpose is to reclaim only the heat content of air, vapors, gases, or fluids that are being expelled through the exhaust sys-
trained. A person who has become proficient in performing a skill reliably and safely through instruction and practice/field experience acceptable to the Authority Having Jurisdiction. [NFPA 96:3.3.49]

**Trained.** A person who has become proficient in performing a skill reliably and safely through instruction and practice/field experience acceptable to the Authority Having Jurisdiction.

**Transition Gas Riser.** A listed or approved section or sections of pipe and fittings used to convey fuel gas and installed in a gas piping system for the purpose of providing a transition from belowground to aboveground.

**Traps.** A cuplike or U-shaped configuration located on the inside of a duct system component where liquids can accumulate. [NFPA 96:3.3.51]

**Type B Gas Vent.** A factory-made gas vent listed by a nationally recognized testing agency for venting listed or approved appliances equipped to burn only gas.

**Type B-W Gas Vent.** A factory-made gas vent listed by a nationally recognized testing agency for venting listed or approved gas-fired vented wall furnaces.

**Type L Gas Vent.** A venting system consisting of listed vent piping and fittings for use with oil-burning appliances listed for use with Type L or with listed gas appliances.

**Unit Heater.** A heating appliance designed for nonresidential space heating and equipped with an integral means for circulation of air.

**Unusually Tight Construction.** Construction where:

1. Walls and ceilings exposed to the outdoors have a continuous water vapor retarder with a rating of 1 perm or less with openings gasketed or sealed.
2. Weatherstriping is on openable windows and doors.
3. Caulking or sealants are applied to areas such as joints around window and door frames, between sole plates and floors, between wall-ceiling joints, between wall panels, and at penetrations for plumbing, electrical, and gas lines and at other openings.

**Use (Material).** The placing in action or making available for service by opening or connecting a container utilized for confinement of material, whether a solid, liquid, or gas.

**Vacuum.** A pressure less than that exerted by the atmosphere.

**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.

**Valve, Stop.** A device in a piping system to shut off the flow of the fluid.

**Valve, Three-Way-Type Stop.** A manually operated valve with one inlet that alternately can stop flow to either of two outlets.

**Valves, Companion or Block.** Pairs of mating stop valves valving off sections of refrigeration systems and arranged so that these sections may be joined before opening these valves or separated after closing them.

**Vent, Gas.** A passageway composed of listed factory-built components assembled in accordance with the manufacturer’s installation instructions for conveying vent gases from appliances or their vent connectors to the outdoors. [NFPA 54:3.3.53]

**Vent Connector, Gas.** That portion of a gas-venting system that connects a listed gas appliance to a gas vent and is installed within the space or area in which the appliance is located.

**Vent Offset.** An arrangement of two or more fittings and pipe installed for the purpose of locating a vertical section of vent pipe in a different but parallel plane with respect to an adjacent section of a vertical vent pipe. [NFPA 54:3.3.102]

**Vented Appliance Categories.**

- **Category I.** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent. [NFPA 54:3.3.5.11.1]
- **Category II.** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that can cause excessive condensate production in the vent. [NFPA 54:3.3.5.11.2]
- **Category III.** An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent. [NFPA 54:3.3.5.11.3]
- **Category IV.** An appliance that operates with a positive vent static pressure and with a vent gas temperature that can cause excessive condensate production in the vent. [NFPA 54:3.3.5.11.4]

**Vented Decorative Appliance.** A vented appliance whose only function is providing an aesthetic effect of flames.

**Vented Wall Furnace.** A self-contained, vented, fuel gas-burning appliance complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building and furnishing heated air, circulated by gravity or by a fan, directly into the space to be heated through openings in the casing. [NFPA 54:3.3.45.7]

**Ventilating Ceiling.** A suspended ceiling containing many small apertures through which air, at low pressure, is forced downward from an overhead plenum dimensioned by the concealed space between the suspended ceiling and the floor or roof above.

**Ventilation System.** All of that equipment intended or installed for the purpose of supplying air to or removing air from, any room or space by mechanical means, other than equipment that is a portion of an environmental heating, cooling, absorption, or evaporative cooling system.

**Venting Collar.** The outlet opening of an appliance provided for connection of the vent system.

**Venting System.** The vent or chimney and its connectors, assembled to form a continuous open passageway from an appliance to the outdoors for the purpose of removing products of combustion. This definition also shall include a venting assembly that is an integral part of an appliance.
**DEFINITIONS**

**Venting System, Gravity-Type.** A system that depends entirely on the heat from the fuel being used to provide the energy required to vent an appliance.

**Venting System, Power-Type.** A system that depends on a mechanical device to provide a positive draft within the venting system.

**Volume, Internal Gross.** The volume as determined from internal dimensions of the container, with no allowance for the volume of the internal parts.

225.0  —  W —

**Wall Heater.** See Vented Wall Furnace.

**Warm Air Furnace.** An environmental heating appliance designed or arranged to discharge heated air through any duct or ducts. This definition shall not include a unit heater.

**Water Heater or Hot-Water-Heating Boiler.** An appliance designed primarily to supply hot water for domestic or commercial purposes and equipped with automatic controls limiting water temperature to a maximum of 210°F (99°C).

226.0  —  X —

No definitions.

227.0  —  Y —

No definitions.

228.0  —  Z —

**Zeotropic.** Blends comprising multiple components of different volatilities that, when used in refrigeration cycles, change volumetric composition and saturation temperatures as they evaporate or condense at constant pressure. [ASHRAE 34:3]
CHAPTER 3
GENERAL REGULATIONS

301.0 General.
301.1 Applicability. This chapter covers general requirements for heating, ventilating, air-conditioning, refrigeration, miscellaneous heat-producing, and energy-utilizing equipment or appliances. Such equipment or appliances shall comply with the requirements of this code.

301.2 Approval. Equipment or appliance shall be approved by the Authority Having Jurisdiction for safe use or comply with applicable nationally recognized standards as evidenced by the listing and label of an approved agency. A list of accepted standards is included in Chapter 17. Defective materials or parts shall be replaced in such a manner as not to invalidate an approval.

301.3 Design of Equipment. The installer or contractor shall furnish satisfactory evidence that the appliance is constructed in accordance with the requirements of this code. The permanently attached label of an approved agency shall be permitted to be accepted as such evidence.

301.4 Electrical Connections. For equipment regulated by this code:

1. Equipment requiring electrical connections of more than 50 volts shall have a positive means of disconnect adjacent to and in sight from the equipment served.
   Exception: Other power disconnect means shall be acceptable where in accordance with NFPA 70.

2. A 120 volt receptacle shall be located within 25 feet (7620 mm) of the equipment for service and maintenance purposes. The receptacle outlet shall be on the supply side of the disconnect switch. The receptacle need not be located on the same level as the equipment.

3. Electrical wiring, controls, and connections to equipment and appliances regulated by this code shall be in accordance with NFPA 70.

301.5 Oil-Burning Appliances. The tank, piping, and valves for appliances burning oil shall be installed in accordance with the requirements of NFPA 31.

301.6 Personnel Protection. A metal guard shall be provided around exposed flywheels, fans, pulleys, belts, and moving machinery that are portions of a heating, ventilating, or refrigerating system.

302.0 Materials – Standards and Alternates.
302.1 Minimum Standards. Listed pipe, pipe fittings, appliances, appurtenances, equipment, materials, and devices used in a mechanical system 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 mechanical systems, or parts thereof, shall be submitted to the Authority Having Jurisdiction for approval prior to being installed.

302.1.1 Marking. Each length of pipe and each pipe fitting, material, and device used in a mechanical system 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 mechanical systems, 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 mechanical standards that appear in specific sections of this code is referenced in Table 1701.1. Standards referenced in Table 1701.1 shall be applied as indicated in the applicable referenced section. A list of additional standards, publications, practices and guides that are not referenced in specific sections of this code appear in Table 1701.2. The documents indicated in Table 1701.2 shall be permitted in accordance with Section 302.2.

302.1.3 Existing Buildings. In existing buildings or premises in which mechanical 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 mechanical systems, 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, dura-
ility, and safety over those prescribed by this code. Technical
documentation shall be submitted to the Authority Having
Jurisdiction to demonstrate equivalency. The Authority Hav-
ing Jurisdiction shall have the authority to approve or disa-
prove 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 Juris-
diction. 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 authority to require tests, as proof of equiva-

302.2.1.1 Tests. Tests shall be made in accordance
with approved testing 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 the Authority Having
Jurisdiction. The Authority Having Jurisdiction
shall have the authority to require tests to be made or
repeated where there is reason to believe that a mate-
rial or device no longer is in accordance with the
requirements on which its approval was based.

302.3 Alternative Engineered Design. An alterna-
tive engineered design shall comply with the intent of the pro-
visions 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 installa-
tion instructions.

302.3.1 Permit Application. The registered design
professional shall indicate on the design documents that
the mechanical system, or parts thereof, is an alterna-
tive engineered design so that it is noted on the construc-
tion permit application. The permit and permanent permit
records shall indicate that an alternative engineered
design was part of the approved installation.

302.3.2 Technical Data. The registered design pro-

302.3.3 Design Documents. The registered design
professional shall provide two complete sets of signed
and sealed design documents for the alternative engi-
neered design for submittal to the Authority Having
Jurisdiction. The design documents shall include floor
plans of the work. Where appropriate, the design docu-
ments shall indicate location, sizing, and loading of
appurtenances, equipment, appliances, and devices.

302.3.4 Design Approval. An approval of an alter-
tative engineered design shall be at the discretion of the
Authority Having Jurisdiction. The exercise of this dis-
cretionary 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.

302.3.5 Design Review. The Authority Having Juris-
diction 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 independ-
ent review of the design documents by a registered
design professional selected by the Authority Having
Jurisdiction and at the expense of the applicant.

302.3.6 Inspection and Testing. The alternative
engineered design shall be tested and inspected in accor-
dance with the submitted testing and inspection plan and
the requirements of this code.

303.0 Installation.

303.1 Listed Appliances. The installation of equipment
and appliances regulated by this code shall be in accordance
with the conditions of the listing, the manufacturer’s installa-
tion instructions and this code. The manufacturer’s installa-
tion and operating instructions shall be attached to the
appliances. Clearances of listed equipment and appliances
from combustible materials shall be as specified in the listing
or on the rating plate.

303.2 Closet or Alcove Installations. Central heating
furnaces and boilers installed in closets or alcoves shall be
listed for such installation. Central heating furnaces not listed
for closet or alcove installation shall be installed in a room or
space having a volume not less than 12 times the total vol-
ume of the furnace. Central heating boilers not listed for
closet or alcove installation shall be installed in a room or
space having a volume 16 times the volume of the boiler.
Where the ceiling height of the room or space exceeds 8 feet
(2438 mm), the volume shall be calculated on the basis of an
8 foot (2438 mm) height.

The installation clearances shall be in accordance with
the appliance listing, shall not be reduced, and shall be
installed in accordance with Section 904.1.

303.3 Unlisted Appliances. Except as otherwise permit-
ted in this code, unlisted equipment and appliances shall be
approved by the Authority Having Jurisdiction prior to being
installed. Unlisted equipment and appliances shall be installed
in accordance with the manufacturer’s installation instruc-
tions and with clearances from combustible materials in
accordance with Section 303.10 or Section 303.10.1.

303.4 Anchorage of Appliances. Appliances designed to
be fixed in position shall be securely fastened in place in
accordance with the manufacturer’s installation instructions.
Supports for appliances shall be designed and constructed to
sustain vertical and horizontal loads within the stress limita-
tions specified in the building code.
303.5 Movement. Movement of appliances with casters shall be limited by a restraining device installed in accordance with the connector and appliance manufacturer’s installation instructions.

303.6 Identification of Equipment. Where more than one heating, cooling, ventilating, or refrigerating system is installed on the roof of a building or within a building, it shall be permanently identified as to the area or space served by the equipment.

303.7 Liquefied Petroleum Gas Facilities. Containers, container valves regulating equipment, and appurtenances for the storage and supply of liquefied petroleum gas shall be installed in accordance with NFPA 58.

303.8 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]

303.8.1 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]

303.8.2 Fasteners. All access locks, screws, and bolts shall be of corrosion-resistant material. [NFPA 54:9.4.1.3]

303.8.3 Installation of Appliances on Roofs. Appliances shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:9.4.2.1]

303.8.4 Clearance. Appliances shall be installed on a well-drained surface of the roof. At least 6 feet (1829 mm) of clearance shall be available between any part of the appliance and the edge of a roof or similar hazard, or rigidly fixed rails, guards, parapets, or other building structures at least 42 inches (1067 mm) in height shall be provided on the exposed side. [NFPA 54:9.4.2.2]

303.8.5 Electrical Power. All appliances requiring an external source of electrical power for its operation shall be provided with the following:

1. A readily accessible electrical disconnecting means within sight of the appliance that completely de-energizes the appliance.

2. A 120-V 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]

303.8.6 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]

303.9 Avoiding Strain on Gas Piping. Appliances shall be supported and connected to the piping so as not to exert undue strain on the connections. [NFPA 54:9.1.17]

303.10 Clearances. Appliances and their vent connectors shall be installed with clearances from combustible material so their operation does not create a hazard to persons or property. Minimum clearances between combustible walls and the back and sides of various conventional types of appliances and their vent connectors are specified in Chapter 8 and Chapter 9. [NFPA 54:9.2.2] Where not provided in this code, listed and unlisted equipment or appliances shall be installed to maintain the required clearances for servicing and to combustible construction in accordance with the listing and the manufacturer’s installation instructions.

303.10.1 Clearance Reduction. Reduced clearances to combustible construction for listed equipment and appliances shall comply with the listing and Table 303.10.1. Where permitted by the manufacturer, and not provided in this code, reduced clearances to combustible construction for unlisted equipment and appliances shall comply with Table 303.10.1.

303.10.1.1 Type I Hood Exhaust System. Reduced clearances for Type I exhaust systems shall be in accordance with Section 507.4.2 through Section 507.4.2.3. Clearances from the duct or the exhaust fan to the interior surface of enclosures of combustible construction shall be in accordance with Section 510.7.3 and clearances shall not be reduced.

303.10.1.2 Product Conveying Ducts. Reduced clearances to combustibles construction for product conveying ducts shall be in accordance with Section 506.10.3 through Section 506.11.6.3.

303.10.1.3 Solid-Fuel Burning Appliances. For solid-fuel burning appliances, the clearance, after reduction, shall not be less than 12 inches (305 mm) to combustible walls and not less than 18 inches (457 mm) to combustible ceilings. The clearance, after reduction, shall be permitted to be less than 12 inches (305 mm) to combustible walls and less than 18 inches (457 mm) to combustible ceilings where the solid-fuel burning appliances are listed for lesser clearances. Solid-fuel burning appliances listed for lesser clearances shall be permitted to be installed in accordance with the manufacturer’s instructions and their listing.

303.11 Installation in Commercial Garages. Appliances installed in enclosed, basement, and underground parking structures shall be installed in accordance with NFPA 88A. [NFPA 54:9.1.11.1]

303.11.1 Repair Garages. Appliances installed in repair garages shall be installed in accordance with NFPA 30A. [NFPA 54:9.1.11.2]

303.12 Installation in Aircraft Hangars. Heaters in aircraft hangars shall be installed in accordance with NFPA 409. [NFPA 54:9.1.12]
304.0 Accessibility for Service.

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

Unless otherwise specified, not less than 30 inches (762 mm) in depth, width, and height of working space shall be provided.

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

304.2 Sloped Roof. Where equipment or appliances that require service are installed on a roof having a slope of 4 units vertical in 12 units horizontal (33 percent slope) or more, a level platform of not less than 30 inches by 30 inches (762 mm by 762 mm) shall be provided at the service side of the equipment or appliance.

304.3 Access to Appliances on Roofs. Appliances located on roofs or other elevated locations shall be accessible. [NFPA 54:9.4.3.1]

304.3.1 Access. Buildings exceeding 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. [NFPA 54:9.4.3.2]

304.3.1.1 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 trapdoors shall be not less than 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.

Not less than 6 feet (1829 mm) of clearance shall be between the access opening and the edge of the roof or similar hazard, or rigidly fixed rails or guards not less than 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 not less than 42 inches (1067 mm) in height. [NFPA 54:9.4.3.3]

304.3.1.2 Permanent Ladders. Permanent ladders required by Section 304.3.1.1 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.
4. Rungs spacing shall not exceed 12 inches (305 mm) on center, and each rung shall be capable of supporting a 300 pound (136.1 kg) load.
5. Toe space shall be not less than 6 inches (152 mm).

304.3.2 Permanent Lighting. Permanent lighting shall be provided at the roof access. The switch for such lighting shall be located inside the building near the access means leading to the roof. [NFPA 54:9.4.3.4]

304.4 Appliances in Attics and Under-Floor Spaces. Appliances in residential garages and in adjacent spaces that open to the garage and are not part of the living space of a dwelling unit shall be installed in a separate, enclosed space having access not less than the largest component of the appliance, and not less than 22 inches by 30 inches (559 mm by 762 mm).

304.4.1 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]

304.4.2 Width of Passageway. The passageway shall be unobstructed and shall have solid flooring not less than 24 inches (610 mm) wide from the entrance opening to the appliance. [NFPA 54:9.5.1.2]

304.4.3 Work Platform. A level working platform not less than 30 inches by 30 inches (762 mm by 762 mm) shall be provided in front of the service side of the appliance. [NFPA 54:9.5.2]

**Exception:** A working platform need not be provided where the furnace is capable of being serviced from the required access opening. The furnace service side shall not exceed 12 inches (305 mm) from the access opening.

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

305.0 Location.

305.1 Installation in Garages. Appliances in residential garages and in adjacent spaces that open to the garage and are not part of the living space of a dwelling unit shall be installed so that all burners and burner-ignition devices are located not less than 18 inches (457 mm) above the floor unless listed as flame resistant for cabinets or other areas subject to mechanical damage 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.

305.1.2 Access from the Outside. Where appliances installed in separate, enclosed spaces having access only from outside of the garage, such appliances shall be permitted to be installed at floor level, providing the required combustion air is taken from the exterior of the garage. [NFPA 54:9.1.10.3]
305.1.3 Cellulose Nitrate Plastic Storage. Heating equipment located in rooms where cellulose nitrate plastic is stored or processed shall be in accordance with the fire code.

303.13 Pit Location. Where excavation is necessary to install an appliance, it shall extend to a depth shall extend not less than 6 inches (152 mm) below and 12 inches (305 mm) on all sides of the appliance, except on the service side, which shall have 30 inches (762 mm). Where the depth of the excavation for either the appliance or passageway exceeds 12 inches (305 mm), walls shall be lined with concrete or masonry 4 inches (102 mm) above the adjoining ground level.

305.3.2 Air Exhaust and Intake Openings. Outside air exhaust openings and air intake openings shall be located at or above the elevation required by the building code for utilities and attendant equipment or the elevation of the lowest floor, whichever is higher.

Exception: Equipment and appliances 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.

305.2.3 Coastal High Hazard Areas. Mechanical systems in buildings located in coastal high hazard areas shall be in accordance with the requirements of Section 305.2.4 and mechanical systems, pipes, 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.

305.3.2 Air Exhaust and Intake Openings. Outside air exhaust openings and air intake openings shall be located at or above the elevation required by the building code for utilities and attendant equipment or the elevation of the lowest floor, whichever is higher.

305.3.4 Elevator Shaft. Unless required for the functionality and safety of the elevator system, mechanical systems shall not be located in an elevator shaft.

305.4.3 Drainage Pan. Where a water heater is located in an attic, in or on an attic ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly where damage results from a leaking water heater, a waternight pan of corrosion-resistant materials shall be installed beneath the water heater with not less than ¾ of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than 1½ inches (38 mm) in depth.

306.0 Automatic Control Devices. 306.1 General. Heating appliances shall be equipped with a listed device or devices that will shut off the flow of gas to the pilot in the event of ignition failure. Liquefied petroleum gas-air-burning heating appliances shall be equipped with a listed automatic device or devices that will shut off the flow of gas to the pilot in the event of ignition failure.

Exception: The listed shutoff devices shall not be required on range or cooking tops, log lighters, lights, or other open-burner manually operated appliances, or listed appliances not requiring such devices and specific industrial appliances as approved by the Authority Having Jurisdiction.

Heating appliances whose manual fuel controls are not readily accessible from the main portion of the building being heated shall be equipped with remote controls.

Forced-air and gravity-type warm air furnaces shall be equipped with a listed air outlet temperature limit control that cannot be set for temperatures exceeding 250°F (121°C). Such controls shall be located in the bonnet or plenum, within 2 feet (610 mm) of the discharge side of the heating element of gravity furnaces or in accordance with the conditions of listing.

Electric duct heaters shall be equipped with an approved automatic reset air outlet temperature limit control that will limit the outlet air temperature to not exceed 200°F (93°C). The electric elements of the heater shall be equipped with fusible links or a manual reset temperature limit control that will prevent outlet air temperature in excess of 250°F (121°C).

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.
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. The symbol of an approved agency certifying compliance of the equipment with recognized standards.

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).

307.4 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. The factory test pressures or pressures applied.
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 Improper Location.

308.1 General. Piping or equipment shall not be so located as to interfere with the normal use thereof or with the normal operation and use of windows, doors, or other required facilities.

309.0 Workmanship.

309.1 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.

309.2 Concealing Imperfections. It shall be unlawful to conceal cracks, holes, or other imperfections in materials by welding, brazing, or soldering, by using therein or thereon paint, wax, tar, solvent cement, other leak-sealing or repair agent.

309.3 Installation Practices. Mechanical systems shall be installed in a manner that is in accordance with this code, applicable standards, and the manufacturer’s installation instructions.

310.0 Condensate Wastes and Control.

310.1 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 by means of an indirect waste pipe. The waste pipe shall have a slope of not less than 1/8 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 310.3 or Section 310.4 for air-cooling coils or condensing appliances, respectively. Condensate or wastewater shall not drain over a public way.

310.1.1 Condensate Pumps. Where approved by the Authority Having Jurisdiction, condensate pumps shall be installed in accordance with the manufacturer’s installation instructions. Pump discharge shall rise vertically to a point where it is possible to connect to a gravity condensate drain and discharged to an approved disposal point. Each condensing unit shall be provided with a separate sump and interlocked with the equipment to prevent the equipment from operating during a failure. Separate pumps shall be permitted to connect to a single gravity indirect waste where equipped with check valves and approved by the Authority Having Jurisdiction.

310.2 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 310.1. 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 ¼ of an inch (20 mm) nominal pipe size, discharging at a point that is readily observed.

310.2 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.

310.3 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 310.3. 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 310.3 MINIMUM CONDENSATE PIPE SIZE**

<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 manufacturer. The capacity of waste pipes assumes a ¼ 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 90°F</td>
<td>DB 75°F</td>
</tr>
<tr>
<td>WB 73°F</td>
<td>WB 62.5°F</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8

Condensate drain sizing for other slopes or other conditions shall be approved by the Authority Having Jurisdiction.

310.4 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.

310.5 Point of Discharge. Air-conditioning condensate waste pipes shall connect indirectly, except where permitted in Section 310.6, 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.

310.6 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.

310.7 Plastic Fittings. Female plastic screwed fittings shall be used with plastic male fittings and plastic male threads.

311.0 Heating or Cooling Air System.

311.1 Source. A heating or cooling air system shall be provided with return air, outside air, or both. A heating or cooling air system regulated by this code and designed to replace required ventilation shall be arranged to discharge into a conditioned space not less than the amount of outside air specified in Chapter 4.

311.2 Air Filters. Air filters shall be installed in a heating, cooling, or makeup air system. Media-type air filters shall comply with UL 900. Electrostatic and high efficiency particulate filters shall comply with Section 936.0.

Exceptions:

(1) Systems serving single guest rooms or dwelling units shall not require a listed filter.

(2) Air filters used in listed appliances and in accordance with the manufacturer’s instructions.

311.3 Prohibited Source. Outside or return air for a heating or cooling air system shall not be taken from the following locations:

(1) Less than 10 feet (3048 mm) in distance from an appliance vent outlet, a vent opening of a plumbing drainage system, or the discharge outlet of an exhaust fan, unless the outlet is 3 feet (914 mm) above the outside-air inlet.

(2) Less than 10 feet (3048 mm) above the surface of an abutting public way, sidewalk, street, alley, or driveway.

(3) A hazardous or insanitary location, or a refrigeration machinery room as defined in this code.

(4) An area, the volume of which is less than 25 percent of the entire volume served by such system, unless there is a permanent opening to an area the volume of which is equal to 25 percent of the entire volume served.

Exception: Such openings where used for a heating or cooling air system in a dwelling unit shall be permitted
311.4 Return-Air Limitations. Return air from one dwelling unit shall not discharge into another dwelling unit through the heating or cooling air system.

312.0 Plumbing Connections.
312.1 General. Water supply, sanitary drainage, and backflow protection shall be in accordance with the plumbing code.

313.0 Hangers and Supports.
313.1 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.

313.2 Material. Hangers and anchors shall be of sufficient strength to support the weight of the pipe or tubing and its contents. Piping or tubing shall be isolated from incompatible materials.

313.3 Suspended Piping. Suspended piping or tubing shall be supported at intervals not to exceed those shown in Table 313.3.

313.4 Alignment. Piping or tubing shall be supported in such a manner as to maintain its alignment and prevent sagging.

313.5 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.

313.6 Hanger Rod Sizes. Hanger rod sizes shall be not smaller than those shown in Table 313.6.

<table>
<thead>
<tr>
<th>PIPE AND TUBE SIZE (inches)</th>
<th>ROD SIZES (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ - 4</td>
<td>¾</td>
</tr>
<tr>
<td>5 - 8</td>
<td>½</td>
</tr>
<tr>
<td>10 - 12</td>
<td>¾</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

313.7 Gas Piping. Gas piping shall be supported by metal straps or hooks at intervals not to exceed those shown in Table 1310.3.5.1.

314.0 Balancing.
314.1 General. Heating, ventilating, and air-conditioning systems (including hydronic systems) shall be balanced in accordance with one of the following methods:
(1) AABC National Standards for Total System Balance
(2) ACCA Manual B
(3) ASHRAE 111
(4) NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems
(5) SMACNA HVAC Systems Testing, Adjusting, and Balancing

315.0 Louvers in Hurricane Prone Regions.
315.1 General. Louvers located in areas within hurricane-prone regions that are within 1 mile (2 km) of the coastal mean high water line where the basic wind speed is 110 miles per hour (mi/h) (49.2 m/s) or more; or portions of hurricane-prone regions where the basic wind speed is 120 mi/h (53.6 m/s) or more; or Hawaii, as described in ASCE 7 shall be tested in accordance with Section 315.1.1 and Section 315.1.2.

315.1.1 Testing. Louvers that protect air intake or exhaust openings shall be tested in accordance with AMCA 550 for resistance to wind-driven rain.

315.1.2 Impact Resistance Test. Upon request by the Authority Having Jurisdiction, louvers protecting intake and exhaust ventilation ducts that are not fixed in the open position and located within 30 feet (9144 mm) of the grade shall be tested for impact resistance in accordance with AMCA 540.

316.0 Protection of Piping, Tubing, Materials, and Structures.
316.1 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 water piping. Voids around piping or tubing passing through concrete floors on the ground shall be sealed.

316.2 Installation. Piping or tubing shall be installed so that the piping, tubing, or connections will not be 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.

316.3 Corrosion, Erosion, and Mechanical Damage. Piping or tubing subject to corrosion, erosion, or mechanical damage shall be protected in an approved manner.

316.4 Protectively Coated Pipe. Protectively coated pipe or tubing shall be inspected and tested, and a visible void, damage, or imperfection to the pipe coating shall be repaired in an approved manner.

316.5 Fire-Resistant Construction. Piping, tubing, and duct system 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.

316.6 Steel Nail Plates. Plastic piping or tubing, copper or copper alloy piping or tubing, and ducts 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.

Exception: See Section 4310.3.1310.4.3.

316.7 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.

316.7.1 Building Loads. Piping or tubing through concrete or masonry walls shall not be subject to a load from building construction.

316.7.2 Exterior Walls. In exterior walls, annular space between sleeves and pipes or tubing shall be sealed and made watertight, as approved by the Authority Having Jurisdiction. A penetration through fire-resistive construction shall be in accordance with Section 316.5.

316.8 Firewalls. A pipe sleeve through a firewall shall have the space around the pipe or tubing completely sealed with an approved fire-resistive material in accordance with other codes.

316.9 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.
### TABLE 303.10.1
REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION

**[NFPA 54: TABLE 10.2.3]**

<table>
<thead>
<tr>
<th>TYPE OF PROTECTION APPLIED TO AND COVERING ALL SURFACES OF COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION</th>
<th>WHERE THE REQUIRED CLEARANCE WITH NO PROTECTION FROM APPLIANCE, VENT CONNECTOR, OR SINGLE-WALL METAL PIPE IS:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ABOVE (COLUMN 1)</td>
</tr>
<tr>
<td>36 (INCHES)</td>
<td>18 (INCHES)</td>
</tr>
<tr>
<td><strong>ALLOWABLE CLEARANCES WITH SPECIFIED PROTECTION (INCHES)</strong></td>
<td><strong>USE COLUMN 1 FOR CLEARANCES ABOVE APPLIANCE OR HORIZONTAL CONNECTOR. USE COLUMN 2 FOR CLEARANCES FROM APPLIANCES, VERTICAL CONNECTOR, AND SINGLE-WALL METAL PIPE.</strong></td>
</tr>
<tr>
<td>(1) 3½ inch thick masonry wall without ventilated air space</td>
<td>—</td>
</tr>
<tr>
<td>(2) ½ of an inch insulation board over 1 inch glass fiber or mineral wool batts</td>
<td>24</td>
</tr>
<tr>
<td>(3) 0.024 inch (nominal 24 gauge) sheet metal over 1 inch glass fiber or mineral wool batts reinforced with wire on rear face with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(4) 3½ inch thick masonry wall with ventilated air space</td>
<td>—</td>
</tr>
<tr>
<td>(5) 0.024 inch (nominal 24 gauge) sheet metal with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(6) ½ of an inch thick insulation board with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(7) 0.024 inch (nominal 24 gauge) sheet metal with ventilated air space over 0.024 inch (nominal 24 gauge) sheet metal with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(8) 1 inch glass fiber or mineral wool batts sandwiched between two sheets 0.024 inch (nominal 24 gauge) sheet metal with ventilated air space</td>
<td>18</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, °C = (°F-32)/1.8

**Notes:**

1. Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.
2. Clearances shall be measured from the outer surface of the combustible material to the nearest point on the surface of the appliance, disregarding an intervening protection applied to the combustible material.
3. Spacers and ties shall be of noncombustible material. No spacer or tie shall be used directly opposite the appliance or connector.
4. Where clearance reduction systems use a ventilated air space, a provision for air circulation shall be provided as described. [See Figure 303.10.1(2) and Figure 303.10.1(3)]
5. There shall be not less than 1 inch (25.4 mm) between clearance reduction systems and combustible walls and ceilings for reduction systems using a ventilated air space.
6. Where a wall protector is mounted on a single flat wall away from corners, it shall have not less than a 1 inch (25.4 mm) air gap. To provide air circulation, the bottom and top edges, or the side and top edges, or edges shall be left open.
7. Mineral wool batts (blanket or board) shall have a density of not less than 8 pounds per cubic foot (lb/ft³) (128 kg/m³) and a minimum melting point of 1500°F (816°C).
8. Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1 British thermal unit inch per hour square foot degree Fahrenheit [Btu•in/(h•ft²•°F)] [0.1W/(m•K)] or less.
9. There shall be not less than 1 inch (25.4 mm) between the appliance and the protector. In no case shall the clearance between the appliance and the combustible surface be reduced below that allowed in this table.
10. Clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
11. Listed single-wall connectors shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.
Notes:

1 A – Equals the clearance with no protection specified in Table 802.7.3.3 and Table 904.2.2 and in the sections applying to various types of appliances equipment.

2 B – Equals the reduced clearance permitted in accordance with Table 303.10.1.

3 The protection applied to the construction using combustible material shall extend far enough in each direction to make C equal to A.

For SI units: 1 inch = 25.4 mm

Note: Masonry walls shall be permitted to be attached to combustible walls using wall ties. Spacers shall not be used directly behind appliance or connector.

For SI units: 1 inch = 25.4 mm
TABLE 313.3
HANGERS AND SUPPORTS

<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(^1), (^2), (^3)</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(^1), (^2), (^3)</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(^1), (^2), (^3)</td>
<td>Base and each floor, not to exceed 15 feet</td>
</tr>
<tr>
<td>Copper &amp; Copper Alloys</td>
<td>Soldered, Brazed, Threaded, or Mechanical</td>
<td>1(\frac{1}{2}) inches and smaller, 6 feet; 2 inches and larger, 10 feet</td>
<td>Each floor, not to exceed 10 feet(^6)</td>
</tr>
<tr>
<td>Steel Pipe for Water DWV</td>
<td>Threaded or Welded</td>
<td>1(\frac{1}{2}) inch and smaller, 10 feet; 1 inch and larger, 12 feet</td>
<td>Every other floor, not to exceed 25 feet(^5)</td>
</tr>
<tr>
<td>Steel Pipe for Gas</td>
<td>Threaded or Welded</td>
<td>(\frac{1}{2}) inch, 6 feet; (\frac{3}{4}) inch and 1 inch, 8 feet; (1\frac{1}{4}) inches and larger, 10 feet</td>
<td>1(\frac{1}{4}) inch every floor level</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(^4)</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; (1\frac{1}{2}) inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>CPVC-AL-CPVC</td>
<td>Solvent Cemented</td>
<td>(\frac{1}{2}) inch, 5 feet; (\frac{3}{4}) inch, 65 inches; 1 inch, 6 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>Lead</td>
<td>Wiped or Burned</td>
<td>Continuous Support</td>
<td>Not to exceed 4 feet</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>PEX</td>
<td>Cold Expansion, Insert and Compression</td>
<td>1 inch and smaller, 32 inches; (1\frac{1}{4}) inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>PEX-AL-PE</td>
<td>Metal insert and metal compression</td>
<td>(\frac{1}{2}) inch (\frac{3}{4}) inch (1) inch (\text{All sizes } 98) inches</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>PE-RT</td>
<td>Metal insert and metal compression</td>
<td>(\frac{1}{2}) inch (\frac{3}{4}) inch (1) inch (\text{All sizes } 98) inches</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

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

Notes:
1. Support adjacent to joint, not to exceed 18 inches (457 mm).
2. Brace not to exceed 40 feet (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.
401.0 General.
401.1 Applicability. This chapter contains requirements for ventilation air supply, exhaust, and makeup air requirements for occupiable spaces within a building.

402.0 Ventilation Air.
402.1 Occupiable Spaces. Occupiable spaces listed in Table 402.1 shall be designed to have ventilation (outdoor) air for occupants in accordance with this chapter.

402.1.1 Construction Documents. The outdoor air ventilation rate and air distribution assumptions made in the design of the ventilation system shall be clearly identified on the construction documents.

402.1.2 Dwelling. Requirements for ventilation air rate for single-family dwellings shall be in accordance with this chapter or ASHRAE 62.2.

402.1.3 Ventilation in Health Care Facilities. Mechanical ventilation for health care facilities shall be designed and installed in accordance with this code and ASHRAE 170.

402.2 Natural Ventilation. Natural ventilation systems shall be designed in accordance with this section and shall include mechanical ventilation systems designed in accordance with Section 403.0, Section 404.0, or both.

Exceptions:
(1) An engineered natural ventilation system where approved by the Authority Having Jurisdiction need not comply with Section 402.2.
(2) The mechanical ventilation system shall not be required where:
   (a) natural ventilation openings that comply with the requirements of Section 402.2 and are permanently open or have controls that prevent the openings from being closed during periods of expected occupancy
   (b) the zone is not served by heating or cooling equipment. [ASHRAE 62.1:6.4]

402.2.1 Floor Area to Be Ventilated. Spaces, or portions of spaces, to be naturally ventilated shall be located within a distance based on the ceiling height, as determined in accordance with Section 402.2.1.1, Section 402.2.1.2, or Section 402.2.1.3, from operable wall openings in accordance with the requirements of Section 402.2.2. For spaces with ceilings that are not parallel to the floor, the ceiling height shall be determined in accordance with Section 402.2.1.4. [ASHRAE 62.1:6.4.1]

402.2.1.1 Single Side Opening. For spaces with operable openings on one side of the space, the distance from the operable openings shall be not more than \(2H\), where \(H\) is the ceiling height. [ASHRAE 62.1:6.4.1.1]

402.2.1.2 Double Side Opening. For spaces with operable openings on two opposite sides of the space, the distance from the operable openings shall be not more than \(5H\), where \(H\) is the ceiling height. [ASHRAE 62.1:6.4.1.2]

402.2.1.3 Corner Openings. For spaces with operable openings on two adjacent sides of a space, such as two sides of a corner, the distance from the operable openings shall be not more than \(5H\) along a line drawn between the two openings that are farthest apart. Floor area outside that line shall comply with Section 402.2.1.1. [ASHRAE 62.1:6.4.1.3]

402.2.1.4 Ceiling Height. The ceiling height, \(H\), to be used in Section 402.2.1.1 through Section 402.2.1.3 shall be the minimum ceiling height in the space.

Exception: For ceilings that are increasing in height, the distance from the openings is increased, the ceiling height shall be determined as the average height of the ceiling within 20 feet (6096 mm) from the operable openings. [ASHRAE 62.1:6.4.1.4]

402.2.2 Location and Size of Openings. Spaces, or portions of spaces, to be naturally ventilated shall be permanently open to operable wall openings directly to the outdoors, such as two sides of a corner, or portions of spaces, without direct openings to the outdoors, ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and shall have a free area of not less than 8 percent of the area of the interior room. [ASHRAE 62.1:6.4.2]

402.2.3 Control and Accessibility. The means to open required operable openings shall be readily accessible to building occupants where the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems. [ASHRAE 62.1:6.4.3]

402.3 Mechanical Ventilation. Where natural ventilation is not permitted by this section or the building code, mechanical ventilation systems shall be designed, constructed, and installed to provide a method of supply air and exhaust air. Mechanical ventilation systems shall include controls, manual or automatic, that enable the fan system to operate whenever the spaces served are occupied. The system shall be designed to maintain minimum outdoor airflow as required by Section 403.0 under any load conditions.
402.4 Outdoor Air Intake Protection. Required outdoor-air intakes shall be covered with a screen having not less than ¼ of an inch (6.4 mm) openings, and shall have not more than ½ of an inch (12.7 mm) openings.

402.4.1 Weather Protections. Outdoor air intakes that are part of the mechanical ventilation system shall be designed to manage rain entrainment, to prevent rain intrusion, and manage water from snow in accordance with ASHRAE 62.1.

403.0 Ventilation Rates.
403.1 General. The design outdoor air intake flow rate for a ventilation system shall be determined in accordance with Section 403.2 through Section 403.9.4.

403.2 Zone Calculations. Ventilation zone parameters shall be determined in accordance with Section 403.2.1 through Section 403.2.3 for each ventilation zone served by the ventilation system. [ASHRAE 62.1:6.2.2]

403.2.1 Breathing Zone Outdoor Airflow. The outdoor airflow required in the breathing zone ($V_{bz}$) of the occupiable space or spaces in a ventilation zone, i.e., the breathing zone outdoor airflow ($V_{bz}$) shall be not less than the value determined in accordance with Equation 403.2.1.

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z$$  
(Equation 403.2.1)

Where:

$A_z =$ zone floor area, the net occupiable floor area of the ventilation zone, square feet (m²).

$P_z =$ zone population, The number of people in the ventilation zone during typical usage.

$R_p =$ outdoor airflow rate required per person as determined from Table 402.1.

$R_a =$ outdoor airflow rate required per unit area as determined from Table 402.1. [ASHRAE 62.1:6.2.2.1]

403.2.2 Zone Air Distribution Effectiveness. The zone air distribution effectiveness ($E_z$) shall be not greater than the default value determined in accordance with Table 403.2.2. [ASHRAE 62.1:6.2.2.2]

403.2.3 Zone Outdoor Airflow. The zone outdoor airflow ($V_{oz}$), i.e., the outdoor airflow rate that shall be provided to the ventilation zone by the supply air distribution system, shall be determined in accordance with Equation 403.2.3. [ASHRAE 62.1:6.2.2.3]

$$V_{oz} = V_{bz} / E_z$$  
(Equation 403.2.3)

403.3 Single-Zone Systems. For ventilation systems where one or more air handlers supply a mixture of outdoor air and recirculated air to only one ventilation zone, the outdoor air intake flow ($V_{ot}$) shall be determined in accordance with Equation 403.3. [ASHRAE 62.1:6.2.3]

$$V_{ot} = V_{oz}$$  
(Equation 403.3)

403.4 One Hundred Percent Outdoor Air Systems. For ventilation systems where one or more air handlers supply only outdoor air to one or more ventilation zones, the outdoor air intake flow ($V_{ot}$) shall be determined in accordance with Equation 403.4. [ASHRAE 62.1:6.2.4]

$$V_{ot} = \sum \text{all zones } V_{oz}$$  
(Equation 403.4)

403.5 Multiple-Zone Recirculating Systems. For ventilation systems where one or more air handlers supply a mixture of outdoor air and recirculated air to more than one ventilation zone, the outdoor air intake flow ($V_{ot}$) shall be determined in accordance with Section 403.5.1 through Section 403.5.4. [ASHRAE 62.1:6.2.5]

403.5.1 Primary Outdoor Air Fraction. The primary outdoor air fraction ($Z_{pz}$) shall be determined for ventilation zones in accordance with Equation 403.5.1. [ASHRAE 62.1:6.2.5.1]

$$Z_{pz} = V_{oz} / V_{pz}$$  
(Equation 403.5.1)

Where:

$V_{pz}$ is the zone primary airflow, i.e., the primary airflow rate to the ventilation zone from the air handler, including outdoor air and recirculated air.

For VAV-system design purposes, $V_{pz}$ is the lowest zone primary airflow value expected at the design condition analyzed.

It shall be permitted to determine these parameters for only selected zones as outlined in Section 404.0. [ASHRAE 62.1:6.2.5.1]

403.5.2 System Ventilation Efficiency. The system ventilation efficiency ($E_s$) shall be determined in accordance with Table 403.5.2 or Section 404.0. [ASHRAE 62.1:6.2.5.2]

403.5.3 Uncorrected Outdoor Air Intake. The uncorrected outdoor air intake ($V_{ou}$) flow shall be determined in accordance with Equation 403.5.3(1). [ASHRAE 62.1:6.2.5.3]

$$V_{ou} = D \sum \text{all zones } (R_p \cdot P_z) + \sum \text{all zones } (R_a \cdot A_z)$$  
(Equation 403.5.3(1))

The occupant diversity ratio ($D$) shall be determined in accordance with Equation 403.5.3(2) to account for variations in population within the ventilation zones served by the system.

$$D = P_s / \sum \text{all zones } P_z$$  
(Equation 403.5.3(2))

Where the system population ($P_s$) is the total population in the area served by the system.
Equation 403.6.1. *Modulate the ventilation modulated parking garage ventilation systems sensing devices installed to*

> **403.5.4 Outdoor Air Intake.** The design outdoor air intake flow ($V_{o}$) shall be determined in accordance with Equation 403.5.4. [ASHRAE 62.1:6.2.5.4]

$$V_{o} = V_{ou}/E_{v} \quad \text{(Equation 403.5.4)}$$

**403.6 Design for Varying Operating Conditions.** Ventilation systems shall be designed to be capable of providing not less than the minimum ventilation rates required in the breathing zone where the zones served by the system are occupied, including all full and part-load conditions. The minimum outdoor air intake flow shall be permitted to be less than the design value at part-load conditions. [ASHRAE 62.1:6.2.6.1]

**403.6.1 Short-Term Conditions.** Where it is known that peak occupancy will be of short duration, or the ventilation will be varied or interrupted for a short period of time, or both, the design shall be permitted to be based on the average conditions over a time period ($T$) determined in accordance with Equation 403.6.1.

$$T = 3v/V_{bz} \quad \text{(Equation 403.6.1)}$$

Where:

- $T = \text{averaging time period, minutes.}$
- $v = \text{the volume of the ventilation zone for which averaging is being applied, cubic foot (m}^3).$
- $V_{bz} = \text{the breathing zone outdoor airflow determined calculated in accordance with Equation 403.2.1 and design value of the zone population ($P_z$), cubic foot per minute (cfm) (m}^3/min).}$

Acceptable design adjustments based on this optional provision shall be in accordance with including the following:

1. **Zones with fluctuating occupancy:** The zone population ($P_z$) shall be permitted to be averaged over time ($T$).
2. **Zones with intermittent interruption of supply air:** The average outdoor airflow supplied to the breathing zone over time ($T$) shall be not less than the breathing zone outdoor airflow ($V_{bz}$) calculated using Equation 403.2.1.
3. **Systems with intermittent closure of the outdoor air intake:** The average outdoor air intake over time ($T$) shall be not less than the minimum outdoor air intake ($V_{o}$) calculated using Equation 403.3, Equation 403.4, or Equation 403.5.4. [ASHRAE 62.1:6.2.6.2]

**403.7 Exhaust Ventilation.** Exhaust airflow shall be provided in accordance with the requirements in Table 403.7. Exhaust makeup air shall be permitted to be a combination of outdoor air, recirculated air, and transfer air.

**403.7.1 Parking Garages.** Exhaust rate for parking garages shall be in accordance with Table 403.7. Exhaust rate shall not be required for enclosed parking garages having a floor area of 1000 square feet (92.9 m$^2$) or less and used for the storage of 5 or less vehicles.

**403.7.2 Enclosed Parking Garages.** Mechanical ventilation systems for enclosed parking garages shall operate continuously.

**Exceptions:**

1. Mechanical ventilation systems shall be permitted to operate intermittently where the system is designed to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices.
2. Approved automatic carbon monoxide sensing devices, and nitrogen dioxide detectors shall be permitted to be employed to modulate the ventilation system to not exceed a maximum average concentration of carbon monoxide of 50 parts per million of carbon monoxide, or 1 part per million nitrogen dioxide during an eight-hour period with a concentration of not more than 200 parts per million for carbon monoxide, or 5 parts per million nitrogen dioxide, for a period not exceeding one hour. Automatic carbon monoxide sensing devices installed to modulated parking garage ventilation systems shall be approved in accordance with Section 301.2.

**403.8 Dynamic Reset.** The system shall be permitted to be designed to reset the outdoor air intake flow ($V_{o}$), the space or ventilation zone airflow ($V_{o}$), as operating conditions change, or both. [ASHRAE 62.1:6.2.7]

**403.9 Air Classification and Recirculation.** Air shall be classified, and its recirculation or transfer shall be limited in accordance with Section 403.9.1 through Section 403.9.4. [ASHRAE 62.1:5.16] Recirculated air shall not be taken from prohibited locations in accordance with Section 311.3.

**403.9.1 Class 1 Air.** Recirculation or transfer of Class 1 air to other spaces shall be permitted. [ASHRAE 62.1:5.16.3.1]

**403.9.2 Class 2 Air.** Recirculation of Class 2 air within the space of origin shall be permitted. Recirculation or transfer of Class 2 air to other Class 2 or Class 3 spaces shall be permitted, provided the other spaces are used for the same or similar purpose or task and involve the same or similar pollutant sources as the Class 2 space. Transfer of Class 2 air to toilet rooms shall be permitted. Recirculation or transfer of Class 2 air to Class 4 spaces shall be permitted. Class 2 air shall not be recirculated or transferred to Class 1 spaces. Where using an energy recovery device, recirculation from leakage, carryover, or transfer from the exhaust side of the energy recovery device shall be permitted and the recirculated Class 2 air shall not exceed 10 percent of the outdoor air intake flow. [ASHRAE 62.1:5.16.3.2]
403.9.3 Class 3 Air. Recirculation of Class 3 air within the space of origin shall be permitted. Class 3 air shall not be recirculated or transferred to other spaces. Where using an energy recovery device, recirculation from leakage, carryover, or transfer from the exhaust side of the energy recovery device shall be permitted and the recirculated Class 3 air shall not exceed 5 percent of the outdoor air intake flow. [ASHRAE 62.1:5.16.3.3]

403.9.4 Class 4 Air. Class 4 air shall not be recirculated or transferred to any other space or be recirculated within the space of origin. [ASHRAE 62.1:5.16.3.4]

404.0 Multiple-Zone Systems.

404.1 General. This section presents an alternative procedure for calculating the system ventilation efficiency \( (E_v) \) where values in Table 403.5.2 are not used. The system ventilation efficiency shall equal the lowest zone ventilation efficiency among the ventilation zones served by the air handler in accordance with Equation 404.1. [ASHRAE 62.1:A1.3]

\[
E_v = \text{minimum (} E_{vz} \text{)} 
\]

(Equation 404.1)

404.2 Average Outdoor Air Fraction. The average outdoor air fraction \( (X_s) \) for the ventilation system shall be determined in accordance with Equation 404.2.

\[
X_s = \frac{V_{out}}{V_{ps}} 
\]

(Equation 404.2)

The uncorrected outdoor air intake \( (V_{out}) \) shall be determined in accordance with Section 403.5.3, and the system primary airflow \( (V_{ps}) \) shall be determined at the condition analyzed. [ASHRAE 62.1:A1.1]

404.3 Zone Ventilation Efficiency. The zone ventilation efficiency \( (E_{vz}) \) shall be the efficiency with which a system distributes outdoor air from the intake to an individual breathing zone, and shall be determined in accordance with Section 404.3.1 or Section 404.3.2. [ASHRAE 62.1:A1.2]

404.3.1 Single Supply Systems. For single supply systems, where the air supplied to a ventilation zone is a mixture of outdoor air and system-level recirculated air, zone ventilation efficiency \( (E_{vz}) \) shall be determined in accordance with Equation 404.3.1. Examples of single supply systems include constant-volume reheat, single-duct VAV, single-fan dual-duct, and multizone systems.

\[
E_{vz} = 1 + X_s - Z_{pz} 
\]

(Equation 404.3.1)

The average outdoor air fraction for the system \( (X_s) \) shall be determined in accordance with Equation 404.2 and the primary outdoor air fraction for the zone \( (Z_{pz}) \) shall be determined in accordance with Section 403.5.1. [ASHRAE 62.1:A1.2.1]

404.3.2 Secondary-Recirculation Systems. For secondary-recirculation systems where the supply air or a portion thereof to each ventilation zone is recirculated air (air that has not been directly mixed with outdoor air) from other zones, zone ventilation efficiency \( (E_{vz}) \) shall be determined in accordance with Equation 404.3.2(1). Examples of secondary-recirculation systems include dual-fan dual-duct and fan-powered mixing-box systems, and systems that include transfer fans for conference rooms.

\[
E_{vz} = \frac{(F_a + X_s F_b - Z_{pz} E_p F_c)}{F_a} 
\]

(Equation 404.3.2(1))

The system air fractions \( F_a, F_b, \) and \( F_c \) shall be determined in accordance with Equation 404.3.2(2), Equation 404.3.2(3), and Equation 404.3.2(4). The zone primary air fraction \( (E_p) \) shall be determined in accordance with Equation 404.3.2(5). For single-zone and single-supply systems \( E_p \) shall equal to 1.0. The zone secondary recirculation fraction \( (E_r) \) shall be determined by the designer based on system configuration. The zone air distribution effectiveness \( (E_z) \) shall be determined in accordance with Section 403.2.2. [ASHRAE 62.1:A1.2.2]

\[
F_a = E_p + (1 - E_p) E_r 
\]

(Equation 404.3.2(2))

\[
F_b = E_p 
\]

(Equation 404.3.2(3))

\[
F_c = 1 - (1 - E_z) (1 - E_r) (1 - E_p) 
\]

(Equation 404.3.2(4))

\[
E_p = \frac{V_{ps}}{V_{dz}} 
\]

(Equation 404.3.2(5))

Where:
- \( E_p \) - Primary air fraction: The fraction of primary air in the discharge air to the ventilation zone.
- \( E_r \) - Secondary recirculation fraction: In systems with secondary recirculation of return air, the fraction of secondary recirculated air to the zone that is representative of average system return air rather than air directly recirculated from the zone.
- \( E_{vz} \) - Zone ventilation efficiency: The efficiency with which the system distributes air from the outdoor air intake to the breathing zone, \( E_z \) is determined in accordance with Section 403.2.2.
- \( F_a \) - Supply air fraction: The fraction of supply air to the ventilation zone from sources or air outside the zone.
- \( F_b \) - Mixed air fraction: The fraction of supply air to the ventilation zone from fully mixed primary air.
- \( F_c \) - Outdoor air fraction: The fraction of outdoor air to the ventilation zone from sources of air outside the zone.
- \( V_{dz} \) - Zone discharge airflow: The expected discharge (supply) airflow to the zone that includes primary airflow and secondary recirculated airflow, cfm (m³/min).
$V_{pz}$ - Zone primary airflow: Determine in accordance with Section 403.5.1.

$X_S$ - Average outdoor air fraction: At the primary air handler, the fraction of outdoor air intake flow in the system primary airflow.

$Z_{pz}$ - Primary outdoor air fraction: The outdoor air fraction required in the primary air supplied to the ventilation zone prior to the introduction of secondary recirculation air. [ASHRAE 62.1:A3]
### TABLE 402.1
MINIMUM VENTILATION RATES IN BREATHING ZONE$^{1,2}$

[ASHRAE 62.1: TABLE 6.2.2.1]

<table>
<thead>
<tr>
<th>Occupancy Category$^4$</th>
<th>People Outdoor Air Rate $R_p$ (Cfm/Person)</th>
<th>Area Outdoor Air Rate $R_A$ (Cfm/ft$^2$)</th>
<th>Default Occupant Density$^3$ (people/1000 ft$^2$)</th>
<th>Air Class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correctional Facilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Booking/waiting</td>
<td>7.5</td>
<td>0.06</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Cell</td>
<td>5</td>
<td>0.12</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Day room</td>
<td>5</td>
<td>0.06</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Guard stations</td>
<td>5</td>
<td>0.06</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td><strong>Educational Facilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art classroom</td>
<td>10</td>
<td>0.18</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Classrooms (ages 5-8)</td>
<td>10</td>
<td>0.12</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Classrooms (age 9 plus)</td>
<td>10</td>
<td>0.12</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Computer lab</td>
<td>10</td>
<td>0.12</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Daycare (through age 4)</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Daycare sickroom</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Lecture classroom$^6$</td>
<td>7.5</td>
<td>0.06</td>
<td>65</td>
<td>1</td>
</tr>
<tr>
<td>Lecture hall (fixed seats)$^7$</td>
<td>7.5</td>
<td>0.06</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Media center$^8$</td>
<td>10</td>
<td>0.12</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Multi-use assembly$^8$</td>
<td>7.5</td>
<td>0.06</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Music/theater/dance$^8$</td>
<td>10</td>
<td>0.06</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Science laboratories</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>University/college laboratories</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Wood/metal shop</td>
<td>10</td>
<td>0.18</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td><strong>Food and Beverage Service</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bars, cocktail lounges</td>
<td>7.5</td>
<td>0.18</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>Cafeteria/fast food dining</td>
<td>7.5</td>
<td>0.18</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>Kitchen (cooking)</td>
<td>7.5</td>
<td>0.12</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Restaurant dining rooms</td>
<td>7.5</td>
<td>0.18</td>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break rooms$^7$</td>
<td>5</td>
<td>0.06</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Coffee stations$^9$</td>
<td>5</td>
<td>0.06</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Conference/meeting$^8$</td>
<td>5</td>
<td>0.06</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Corridors$^9$</td>
<td>–</td>
<td>0.06</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Occupiable storage rooms for liquids or gels$^9$</td>
<td>5</td>
<td>0.12</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Hotels, Motels, Resorts, Dormitories</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barracks sleeping areas$^9$</td>
<td>5</td>
<td>0.06</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Bedroom/living room$^9$</td>
<td>5</td>
<td>0.06</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Laundry rooms, central</td>
<td>5</td>
<td>0.12</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Laundry rooms within dwelling units</td>
<td>5</td>
<td>0.12</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Lobbies/pre-function$^9$</td>
<td>7.5</td>
<td>0.06</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Multipurpose assembly$^9$</td>
<td>5</td>
<td>0.06</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td><strong>Office Buildings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Rooms</td>
<td>5</td>
<td>0.12</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Main entry lobbies$^9$</td>
<td>5</td>
<td>0.06</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Occupiable storage rooms for dry materials</td>
<td>5</td>
<td>0.06</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Office space$^9$</td>
<td>5</td>
<td>0.06</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Reception areas$^9$</td>
<td>5</td>
<td>0.06</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Telephone/data entry$^9$</td>
<td>5</td>
<td>0.06</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td><strong>Miscellaneous Spaces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank or bank lobbies$^9$</td>
<td>7.5</td>
<td>0.06</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Bank vaults/safe deposit$^9$</td>
<td>5</td>
<td>0.06</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Computer (not printing)$^9$</td>
<td>5</td>
<td>0.06</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Freezer and refrigerated spaces (&lt;50°F)$^9$</td>
<td>10</td>
<td>–</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>General manufacturing (excludes heavy industrial and processes using chemicals)</td>
<td>10</td>
<td>0.18</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Pharmacy (prep. area)</td>
<td>5</td>
<td>0.18</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Photo studios</td>
<td>5</td>
<td>0.12</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
### TABLE 402.1 (continued)

**MINIMUM VENTILATION RATES IN BREATHING ZONE\(^1,2\)**

[ASHRAE 62.1: TABLE 6.2.2.1]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY(^4)</th>
<th>PEOPLE OUTDOOR Air Rate (R_p) (Cfm/Person)</th>
<th>AREA OUTDOOR Air Rate (R_A) (Cfm/Ft(^2))</th>
<th>DEFAULT OCCUPANT DENSITY(^3) (people/1000 ft(^2))</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shipping/receiving(^b)</td>
<td>10</td>
<td>0.12</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sorting, packing, light assembly</td>
<td>7.5</td>
<td>0.12</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Telephone closets</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Transportation waiting(^c)</td>
<td>7.5</td>
<td>0.06</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Warehouses(^b)</td>
<td>10</td>
<td>0.06</td>
<td>–</td>
<td>2</td>
</tr>
</tbody>
</table>

**PUBLIC ASSEMBLY SPACES**

| Auditorium seating area\(^b\) | 5                                             | 0.06                                          | 150                                              | 1         |
| Courtrooms\(^b\)              | 5                                             | 0.06                                          | 70                                               | 1         |
| Legislative chambers\(^b\)    | 5                                             | 0.06                                          | 50                                               | 1         |
| Libraries                    | 5                                             | 0.12                                          | 10                                               | 1         |
| Lobbies\(^b\)                | 5                                             | 0.06                                          | 150                                              | 1         |
| Museums (children’s)         | 7.5                                           | 0.12                                          | 40                                               | 1         |
| Museums/galleries\(^a\)       | 7.5                                           | 0.06                                          | 40                                               | 1         |
| Places of religious worship\(^b\) | 5                                           | 0.06                                          | 120                                              | 1         |

**RESIDENTIAL**

| Common corridors\(^b\)       | –                                             | 0.06                                          | –                                               | 1         |
| Dwelling unit\(^c, d, b\)    | 5                                             | 0.06                                          | See footnote\(^3\)                               | 1         |

**RETAIL**

| Sales (except as below)      | 7.5                                           | 0.12                                          | 25                                               | 2         |
| Barber shop\(^b\)           | 7.5                                           | 0.06                                          | 25                                               | 2         |
| Beauty and nail salons      | 20                                            | 0.12                                          | 25                                               | 2         |
| Coin-operated laundries     | 7.5                                           | 0.12                                          | 20                                               | 2         |
| Mall common areas\(^b\)      | 7.5                                           | 0.06                                          | 40                                               | 1         |
| Pet shops (animal areas)     | 7.5                                           | 0.18                                          | 10                                               | 2         |
| Supermarket\(^d\)            | 7.5                                           | 0.06                                          | 8                                                | 1         |

**SPORTS AND ENTERTAINMENT**

| Bowling alley (seating)      | 10                                            | 0.12                                          | 40                                               | 1         |
| Disco/dance floors\(^b\)     | 20                                            | 0.06                                          | 100                                              | 2         |
| Gambling casinos             | 7.5                                           | 0.18                                          | 120                                              | 1         |
| Game arcades                 | 7.5                                           | 0.18                                          | 20                                               | 1         |
| Gym, sports arena (play area)\(^a\) | 20                                         | 0.18                                          | 7                                                | 2         |
| Health club/aerobics room    | 20                                            | 0.06                                          | 40                                               | 2         |
| Health club/weight rooms     | 20                                            | 0.06                                          | 10                                               | 2         |
| Spectator areas\(^e\)        | 7.5                                           | 0.06                                          | 150                                              | 1         |
| Stages, studios\(^e, b\)     | 10                                            | 0.06                                          | 70                                               | 1         |
| Swimming (pool & deck)\(^c\) | –                                             | 0.48                                          | –                                               | 2         |

For SI units: 1 cubic foot per minute = 0.0283 m\(^3\)/min, 1 square foot = 0.0929 m\(^2\)

**Notes:**

1. This table applies to no-smoking areas. Rates for smoking-permitted spaces shall be determined using other methods.
2. Volumetric airflow rates are based on a dry air density of 0.075 pounds of dry air per cubic foot (lbda/ft\(^3\)) (1.201 kgda/m\(^3\)), which corresponds to dry air at a barometric pressure of 1 atm (101 kPa) and an air temperature of 70°F (21°C). Rates shall be permitted to be adjusted for actual density, but such adjustment is not required for compliance with this chapter.
3. The default occupant density shall be used where actual occupant density is not known.
4. Where the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities, and building construction shall be used.

**ITEM-SPECIFIC NOTES FOR TABLE 402.1**

\(a\) For high school and college libraries, use the values shown for “Public Assembly Spaces – Libraries” shall be used.

\(b\) Rates shown are capable of being insufficient where stored materials include those having potentially harmful emissions.

\(c\) Rate does not allow for humidity control. Additional ventilation or dehumidification shall be permitted to remove moisture. “Deck area” refers to the area surrounding the pool that would be expected to be is capable of being wetted during normal pool use, i.e., where the pool is occupied. Deck area that is not expected to be wetted shall be designated as a space type (for example, “spectator area”) an occupancy category.

\(d\) Rate does not include special exhaust for stage effects, e.g., such as dry ice vapors, and smoke.

\(e\) Where combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation, source control, or both shall be provided.

\(f\) Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.

\(g\) Air from one residential dwelling shall not be recirculated or transferred to other spaces outside of that dwelling.

\(h\) Ventilation air for this occupancy category shall be permitted to be reduced to zero where the space is in occupied-standby mode.
### TABLE 403.2.2
ZONE AIR DISTRIBUTION EFFECTIVENESS[^1,2,3,4,5]
[ASHRAE 62.1: TABLE 6.2.2.2]

<table>
<thead>
<tr>
<th>AIR DISTRIBUTION CONFIGURATION</th>
<th>$E_z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling supply of cool air.</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceiling supply of warm air and floor return.</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceiling supply of warm air 15°F or more above space temperature and ceiling return.</td>
<td>0.8</td>
</tr>
<tr>
<td>Ceiling supply of warm air less than 15°F above space temperature and ceiling return provided that the 150 feet per minute (fpm) supply air jet reaches to within 4.5 feet of floor level.</td>
<td>1.0[^6]</td>
</tr>
<tr>
<td>Floor supply of cool air and ceiling return provided that the vertical throw is more than 50 fpm at a height of 4.5 feet or more above the floor.</td>
<td>1.0</td>
</tr>
<tr>
<td>Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification, or underfloor air distribution systems where the vertical throw is 50 fpm or less at a height of 4.5 feet above the floor.</td>
<td>1.2</td>
</tr>
<tr>
<td>Floor supply of warm air and floor return.</td>
<td>1.0</td>
</tr>
<tr>
<td>Floor supply of warm air and ceiling return.</td>
<td>0.7</td>
</tr>
<tr>
<td>Makeup supply drawn in on the opposite side of the room from the exhaust, return, or both.</td>
<td>0.8</td>
</tr>
<tr>
<td>Makeup supply drawn in near to the exhaust, return, or both locations.</td>
<td>0.5</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8, 1 foot per minute = 0.005 m/s, 1 foot = 304.8 mm

**Notes:**
[^1]: “Cool air” is air cooler than space temperature.
[^2]: “Warm air” is air warmer than space temperature.
[^3]: “Ceiling supply” includes any point above the breathing zone.
[^4]: “Floor supply” includes any point below the breathing zone.
[^5]: As an alternative to using the above values, $E_z$ shall be permitted to be regarded as equal to air change effectiveness determined in accordance with ASHRAE 129 for air distribution configurations except unidirectional flow.
[^6]: For lower velocity supply air, $E_z = 0.8$

### TABLE 403.5.2
SYSTEM VENTILATION EFFICIENCY[^1,2,3]
[ASHRAE 62.1: TABLE 6.2.5.2]

<table>
<thead>
<tr>
<th>MAX ($Z_p z$)</th>
<th>$E_v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 0.15$</td>
<td>1.0</td>
</tr>
<tr>
<td>$0.25$</td>
<td>0.9</td>
</tr>
<tr>
<td>$\leq 0.35$</td>
<td>0.8</td>
</tr>
<tr>
<td>$0.45$</td>
<td>0.7</td>
</tr>
<tr>
<td>$\leq 0.55$</td>
<td>0.6</td>
</tr>
<tr>
<td>$&gt; 0.55$</td>
<td>Use Section 404.0</td>
</tr>
</tbody>
</table>

**Notes:**
[^1]: “Max $Z_p z$” refers to the largest value of $Z_p z$, calculated in accordance with Equation 403.5.1, among the ventilation zones served by the system.
[^2]: For values of Max ($Z_p z$) between 0.15 and 0.55, the corresponding value of $E_v$ shall be permitted to be determined by interpolating the values in the table.
[^3]: The values of $E_v$ in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the uncorrected outdoor air intake ($V_{ou}$) to the total zone primary airflow for the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table is capable of resulting in unrealistically low values of $E_v$ and the use of Section 404.0 is capable of yielding more practical results.
## TABLE 403.7
**MINIMUM EXHAUST RATES**
[ASHRAE 62.1: TABLE 6.5]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY8</th>
<th>EXHAUST RATE (cfm/unit)</th>
<th>EXHAUST RATE (cfm/ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arenas2</td>
<td>–</td>
<td>0.50</td>
<td>1</td>
</tr>
<tr>
<td>Art classrooms</td>
<td>–</td>
<td>0.70</td>
<td>2</td>
</tr>
<tr>
<td>Auto repair rooms1</td>
<td>–</td>
<td>1.50</td>
<td>2</td>
</tr>
<tr>
<td>Barber shops</td>
<td>–</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>Beauty and nail salons</td>
<td>–</td>
<td>0.60</td>
<td>2</td>
</tr>
<tr>
<td>Cells with toilet</td>
<td>–</td>
<td>1.00</td>
<td>2</td>
</tr>
<tr>
<td>Copy, printing rooms</td>
<td>–</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>Darkrooms</td>
<td>–</td>
<td>1.00</td>
<td>2</td>
</tr>
<tr>
<td>Educational science laboratories</td>
<td>–</td>
<td>1.00</td>
<td>2</td>
</tr>
<tr>
<td>Janitor closets, trash rooms, recycling</td>
<td>–</td>
<td>1.00</td>
<td>3</td>
</tr>
<tr>
<td>Kitchens – commercial</td>
<td>–</td>
<td>0.70</td>
<td>2</td>
</tr>
<tr>
<td>Kitchenettes</td>
<td>–</td>
<td>0.30</td>
<td>2</td>
</tr>
<tr>
<td>Locker rooms for athletic, industrial and health care facilities</td>
<td>–</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>Other locker rooms</td>
<td>–</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>Shower rooms10</td>
<td>20/50</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Paint spray booths</td>
<td>–</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Parking garages3</td>
<td>–</td>
<td>0.75</td>
<td>2</td>
</tr>
<tr>
<td>Pet shops (animal areas)</td>
<td>–</td>
<td>0.90</td>
<td>2</td>
</tr>
<tr>
<td>Refrigerating machinery rooms⁶</td>
<td>–</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Residential – kitchens⁷</td>
<td>50/100</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Soiled laundry storage rooms</td>
<td>–</td>
<td>1.00</td>
<td>3</td>
</tr>
<tr>
<td>Storage rooms, chemical</td>
<td>–</td>
<td>1.50</td>
<td>4</td>
</tr>
<tr>
<td>Toilets – private⁵,⁹</td>
<td>25/50</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Toilets – public⁴,⁹</td>
<td>50/70</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Woodwork shop/classrooms</td>
<td>–</td>
<td>0.50</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.0283 m³/min, 1 square foot = 0.0929 m²

**Notes:**

1. Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.
2. Where combustion equipment is intended to be used on the playing surface, additional dilution ventilation, source control, or both shall be provided.
3. Exhaust rate shall not be required for where two or more sides comprise walls that are at least 50 percent open or parking garages as defined in accordance with the building code outside.
4. Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur, e.g., toilets in theaters, schools, and sports facilities. Otherwise the lower rate shall be permitted to be used otherwise.
5. Rate is for a toilet room intended to be occupied by one person at a time. For continuous system operation during normal hours of use, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
6. For refrigeration machinery rooms, the exhaust rate shall comply with Chapter 11.
7. For continuous system operation, the lower rates shall be permitted. Otherwise the higher rate shall be used.
8. For unlisted occupancies for a proposed space not listed in the table, the requirements for the listed occupancy that is most similar in terms of occupant density and occupancy type shall be used.
9. Exhaust air that has been cleaned in accordance with the criteria of Class 1 shall be permitted to be recirculated.
10. Rate is per shower head.
CHAPTER 5
EXHAUST SYSTEMS

501.0 General.
501.1 Applicability. This chapter includes requirements for environmental air ducts, product-conveying systems, and commercial hoods and kitchen ventilation. Part I addresses environmental air ducts and product conveying systems. Part II addresses commercial hoods and kitchen ventilation.

502.0 Termination.
502.1 Exhaust Opening Protection. Exhaust openings terminating to the outdoors shall be covered with a corrosion-resistant screen having not less than 1/4 of an inch (6.4 mm) openings, and shall have not more than 1/2 of an inch (12.7 mm) openings.

Exception: Clothes dryers.

502.2 Termination of Exhaust Ducts. Exhaust ducts shall terminate in accordance with Section 502.2.1 through Section 502.2.3.

502.2.1 Environmental Air Ducts. Environmental air duct exhaust shall terminate not less than 3 feet (914 mm) from a property line, 10 feet (3048 mm) from a forced air inlet, and 3 feet (914 mm) from openings into the building. Environmental exhaust ducts shall not discharge onto a public walkway.

502.2.2 Product Conveying Ducts. Ducts conveying explosive or flammable vapors, fumes, or dusts shall terminate not less than 30 feet (9144 mm) from a property line, 10 feet (3048 mm) from openings into the building, 6 feet (1829 mm) from exterior walls or roofs, 30 feet (9144 mm) from combustible walls or openings into the building that are in the direction of the exhaust discharge, and 10 feet (3048 mm) above adjoining grade.

Other product-conveying outlets shall terminate not less than 10 feet (3048 mm) from a property line, 3 feet (914 mm) from exterior walls or roofs, 10 feet (3048 mm) from openings into the building, and 10 feet (3048 mm) above adjoining grade.

502.2.3 Commercial Kitchen Ducts. Commercial kitchen exhaust ducts shall terminate in accordance with Section 510.9 or Section 519.5.


503.0 Motors, Fans, and Filters.
503.1 General. Motors and fans shall be sized to provide the required air movement. Motors in areas that contain flammable vapors or dusts shall be of a type approved for such environments. A manually operated control installed at an approved location shall be provided to shut off fans or blowers in flammable vapor or dust systems. Equipment used in operations that generate explosive or flammable vapors, fumes, or dusts shall be interlocked with the ventilation system so that the equipment cannot be operated unless the ventilation fans are in operation. Motors for fans used to convey flammable vapors or dusts shall be located outside the duct or shall be protected with approved shields and dustproofing. Where belts are used, they shall not enter the duct unless the belt and pulley within the duct are enclosed. Motors and fans shall be accessible for servicing and maintenance.

503.2 Fans. Parts of fans in contact with explosive or flammable vapors, fumes, or dusts shall be of nonferrous or non-sparking materials, or their casing shall be lined or constructed of such material. Where the size and hardness of materials passing through a fan are capable of producing a spark, both the fan, and the casing shall be of nonsparking materials. When fans are required to be spark-resistant, their bearings shall not be within the airstream, and parts of the fan shall be grounded. Fans in systems handling materials that are likely to clog the blades, and fans in buffing or woodworking exhaust systems, shall be of the radial-blade or tube-axial type.

Equipment used to exhaust explosive or flammable vapors, fumes, or dusts shall bear an identification plate stating the ventilation rate for which the system was designed.

Fans located in systems conveying corrosives shall be of materials that are resistant to the corrosive or shall be coated with corrosion-resistant materials.

504.0 Environmental Air Ducts.
504.1 General. Where not specified in this chapter, exhaust ducts shall be constructed and installed in accordance with Chapter 6 and shall be airtight as approved by the Authority Having Jurisdiction. Environmental air ducts that have an alternate function as a part of an approved smoke-control system do not require design as Class 1 product-conveying ducts.

Exceptions:
(1) Ductless range hoods where installed in accordance with the manufacturer’s installation instructions.
(2) Condensing clothes dryers where installed in accordance with the manufacturer’s installation instructions.

504.1.1 Backdraft Protection. Exhaust ducts shall terminate outside the building and shall be equipped with backdraft dampers or with motorized dampers that automatically shut where the systems or spaces served are not in use.

Exception: Where the exhaust duct does not discharge into a common exhaust plenum and one of the following:
(1) The exhaust fan runs continuously.
(2) The exhaust duct serves space(s) that are not mechanically heated or cooled.
(3) The space served is maintained at positive pressure.

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504.2 Independent Exhaust Systems. Single or combined mechanical exhaust systems shall be independent of other exhaust systems.

504.3 Domestic Range. Ducts used for domestic kitchen range or cooktop ventilation shall be of metal and shall have smooth interior surfaces.

Exception: Ducts for domestic kitchen downdraft grill-range ventilation installed under a concrete slab floor shall be permitted to be of approved Schedule 40 PVC provided:

(1) The under-floor trench in which the duct is installed shall be completely backfilled with sand or gravel.
(2) Not more than 1 inch (25.4 mm) of 6 inch diameter (152 mm) PVC coupling shall be permitted to protrude above the concrete floor surface.
(3) PVC pipe joints shall be solvent cemented to provide an air and greasetight duct.
(4) The duct shall terminate above grade outside the building and shall be equipped with a backdraft damper.

504.4 Clothes Dryers. A clothes dryer exhaust duct shall not be connected to a vent connector, gas vent, chimney, and shall not terminate into a crawl space, attic, or other concealed space. Exhaust ducts shall not be assembled with screws or other fastening means that extend into the duct and that are capable of catching lint, and that reduce the efficiency of the exhaust system. Exhaust ducts shall be constructed of rigid metallic material. Transition ducts used to connect the dryer to the exhaust duct shall be listed and labeled in accordance with UL 2158A, or installed in accordance with the clothes dryer manufacturer’s installation instructions.

504.4.1 Provisions for Makeup Air. Makeup air shall be provided in accordance with the following:

(1) Makeup air shall be provided for Type 1 clothes dryers in accordance with the manufacturer’s instructions. [NFPA 54:10.4.3.1] Where a closet is designed for the installation of a clothes dryer, an opening of not less than 100 square inches (0.065 m²) for makeup air shall be provided in the door or by other approved means.

(2) Provision for makeup air shall be provided for Type 2 clothes dryers, with a free area of not less than 1 square inch (0.0006 m²) for each 1000 British thermal units per hour (Btu/h) (0.293 kW) total input rating of the dryer(s) installed. [NFPA 54:10.4.3.2]

504.4.2 Domestic Clothes Dryers. Where a compartment or space for a Type 1 clothes dryer is provided, not less than a 4 inch diameter (102 mm) exhaust duct of approved material shall be installed in accordance with Section 504.0.

Type 1 clothes dryer exhaust ducts shall be of rigid metal and shall have smooth interior surfaces. The diameter shall be not less than 4 inches nominal (100 mm), and the thickness shall be not less than 0.016 of an inch (0.406 mm).

504.4.2.1 Length Limitation. Unless otherwise permitted or required by the dryer manufacturer’s instructions and approved by the Authority Having Jurisdiction, domestic dryer moisture exhaust ducts shall not exceed a total combined horizontal and vertical length of 14 feet (4267 mm), including two 90 degree (1.57 rad) elbows. A length of 2 feet (610 mm) shall be deducted for each 90 degree (1.57 rad) elbow in excess of two.

Exception: Where an exhaust duct power ventilator, in accordance with Section 504.4.2.3, is used, the maximum length of the dryer exhaust duct shall be permitted to be in accordance with the dryer exhaust duct power ventilator manufacturer’s installation instructions.

504.4.2.2 Transition Ducts. Listed clothes dryer transition ducts not more than 6 feet (1829 mm) in length shall be permitted to be used to connect the Type 1 dryer to the exhaust ducts. Transition ducts shall not be concealed within construction, and shall be installed in accordance with the manufacturer’s installation instructions.

504.4.2.3 Exhaust Duct Power Ventilators. Dryer exhaust duct power ventilators for single residential clothes dryers shall be listed and labeled in accordance with UL 705 and installed in accordance with the manufacturer’s installation instructions.

504.4.3 Commercial Clothes Dryers. Commercial dryer exhaust ducts shall be installed in accordance with their listings. The installation of commercial clothes dryer exhaust ducts shall comply with the appliance manufacturer’s installation instructions.

504.4.3.1 Exhaust Ducts for Type 2 Clothes Dryers. Exhaust ducts for Type 2 clothes dryers shall comply with the following:

(1) Exhaust ducts for Type 2 clothes dryers shall comply with Section 504.4. [NFPA 54:10.4.5.1]

(2) Exhaust ducts for Type 2 clothes dryers shall be constructed of sheet metal or other noncombustible material. Such ducts shall be equivalent in strength and corrosion resistance to ducts made of galvanized sheet steel not less than 0.0195 of an inch (0.4953 mm) thick. [NFPA 54:10.4.5.2]

(3) Type 2 clothes dryers shall be equipped or installed with lint-controlling means. [NFPA 54:10.4.5.3]

(4) Exhaust ducts for unlisted Type 2 clothes dryers shall be installed with a minimum clearance of not less than 6 inches (152 mm) from adjacent combustible material. Where exhaust ducts for Type 2 clothes dryers are installed with reduced clearances, the adjacent combustible material shall be protected in accordance with Table 303.10.1. [NFPA 54:10.4.5.4]
504.4 Common Exhaust. Where permitted by the clothes dryer manufacturer’s installation instructions, multiple clothes dryers shall be permitted to be installed with a common exhaust. The common exhaust duct shall be constructed of rigid metal and shall be installed in a fire-resistant rated enclosure in accordance with the building code. The duct material shall be of rigid metal with a thickness of not less than 0.020 of an inch (0.508 mm) (24 gauge). The duct enclosure shall be provided with a cleanout opening at the base of not less than 12 inches by 12 inches (305 mm by 305 mm). The exhaust fan shall be located downstream of branch connections and operated continuously and shall be monitored by an approved means.

504.4.5 Duct Supports. Ducts shall be supported in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.

504.5 Heat (Energy) Recovery Ventilators. Heat (energy) recovery ventilators shall be installed in accordance with their listings and comply with the appliance manufacturer’s installation instructions. Non-ducted heat recovery ventilators shall comply with UL 1815. Ducted heat recovery ventilators shall comply with UL 1812. Heat (energy) recovery ventilator ducts shall comply with Chapter 6.

504.6 Gypsum Wallboard Ducts. Bathroom and laundry room exhaust ducts shall be permitted to be of gypsum wallboard subject to the limitations of Section 602.5602.4.2.

505.0 Product-Conveying Systems.

505.1 General. A mechanical ventilation or exhaust system shall be installed to control, capture, and remove emissions generated from product use or handling where required in accordance with the building code or fire code and where such emissions result in a hazard to life or property. The design of the system shall be such that the emissions are confined to the area in which they are generated by air currents, hoods, or enclosures and shall be exhausted by a duct system to a safe location or treated by removing contaminants. Ducts conveying explosives or flammable vapors, fumes, or dusts shall extend directly to the exterior of the building without entering other spaces and shall not extend into or through ducts and plenums.

Exception: Ducts conveying vapor or fumes having flammable constituents less than 25 percent of their Lower Flammability Limit (LFL) shall be permitted to pass through other spaces.

505.1.1 Mechanical Ventilation. A mechanical ventilation system shall be interlocked to operate with the equipment used to produce vapors, fumes, or dusts that are flammable or hazardous.

505.2 Incompatible Materials. Incompatible materials shall not be conveyed in the same system. [NFPA 91:4.2.2]

505.3 Flammability Limit. Unless the circumstances stipulated in Section 505.3.1, Section 505.3.2, or Section 505.3.3 exist, in systems conveying flammable vapors, gases, or dusts, the concentration shall not exceed 25 percent of the lower flammability limit (LFL). [NFPA 91:4.2.3]

505.3.1 Higher Concentrations. Higher concentrations shall be permitted where the exhaust system is designed and protected in accordance with NFPA 69 using one or more of the following techniques:

(1) Combustible concentration reduction
(2) Oxidant concentration reduction
(3) Deflagration suppression
(4) Deflagration pressure containment [NFPA 91:4.2.3.1]

Contaminated air shall not be recirculated to occupied areas unless contaminants have been removed. Air contaminated with explosive or flammable vapors, fumes, or dusts; flammable or toxic gases; or radioactive material shall not be recirculated.

505.3.2 Ovens and Furnaces. Higher concentrations shall be permitted for ovens and furnaces designed and protected in accordance with NFPA 86. [NFPA 91:4.2.3.2]

505.3.3 Deflagration. Higher concentrations shall be permitted where deflagration venting is provided in accordance with NFPA 68. [NFPA 91:4.2.3.3]

505.4 Air-Moving Devices. Air-moving devices shall be sized to establish the velocity required to capture, control, and convey materials through the exhaust system. [NFPA 91:4.2.5]

505.5 Generating Flames, Sparks, or Hot Materials. Operations generating flames, sparks, or hot material such as from grinding wheels and welding shall not be manifolded into an exhaust system that air conveys flammable or combustible materials. [NFPA 91:4.2.6]

505.6 Fire Dampers. Fire dampers shall be permitted to be installed in exhaust systems in accordance with the following:

(1) Where ducts pass through fire barriers
(2) Where a collection system installed on the end of the system is protected with an automatic extinguishing system
(3) Where the duct system is protected with an automatic extinguishing system
(4) Where ducts have been listed with interrupters
(5) Where necessary to facilitate the control of smoke pursuant to the applicable NFPA standards [NFPA 91:4.2.9]

505.6.1 Prohibited. Fire dampers shall not be installed if the material being exhausted is toxic and if a risk evaluation indicates that the toxic hazard is greater than the fire hazard. [NFPA 91:4.2.10]

505.7 Fire Detection and Alarm Systems. Unless the conditions in Section 505.7.1 or Section 505.7.2 exist, fire detection and alarm systems shall not be interlocked to shut down air-moving devices. [NFPA 91:4.2.14]
505.7.1 Automatic Extinguishing System. Where shutdown is necessary for the effective operation of an automatic extinguishing system, it shall be permitted to interlock fire detection and alarm systems to shut down air-moving devices. [NFPA 91:4.2.14.1]

505.7.2 Shut Down Permitted. Where a documented risk analysis acceptable to the Authority Having Jurisdiction shows that the risk of damage from fire and the products of combustion would be higher with air-moving devices operating, it shall be permitted to interlock fire detection and alarm systems to shut down air-moving devices. [NFPA 91:4.2.14.2]

505.8 Product-Conveying Ducts Classification. Product-conveying ducts shall be classified according to their use, as follows:

Class 1 - Ducts conveying nonabrasives, such as smoke, spray, mists, fogs, noncorrosive fumes and gases, light fine dusts, or powders.

Class 2 - Ducts conveying moderately abrasive particulate in light concentrations, such as sawdust and grain dust, and buffing and polishing dust.

Class 3 - Ducts conveying Class 2 materials in high concentrations and highly abrasive materials in low concentrations, such as manganese, steel chips, and coke.

Class 4 - Ducts conveying highly abrasive material in high concentrations.

Class 5 - Ducts conveying corrosives, such as acid vapors.

505.9 Minimum Velocities and Circulation. The velocity and circulation of air in work areas shall be such that contaminant's are captured by an airstream at the area where the emissions are generated and conveyed into a product-conveying duct system. Mixtures within work areas where contaminants are generated shall be diluted to be accordance with Section 505.3 with air that does not contain other contaminants. The velocity of air within the duct shall be not less than set forth in Table 505.9.

Systems conveying particulate matter shall be designed by employing the constant velocity method. Systems conveying explosive or radioactive materials shall be pre-balanced through duct sizing. Other systems shall be permitted to be designed with balancing devices such as dampers. Dampers provided to balance airflow shall be provided with securely fixed minimum-position blocking devices to prevent restricting flow below the required volume or velocity.

505.10 Makeup Air. Makeup air shall be provided to replenish air exhausted by the ventilation system. Makeup air intakes shall be located so as to avoid recirculation of contaminated air within enclosures.

505.11 Hoods and Enclosures. Hoods and enclosures shall be used where contaminants originate in a concentrated area. The design of the hood or enclosure shall be such that air currents created by the exhaust systems will capture the contaminants and transport them directly to the exhaust duct. The volume of air shall be sufficient to dilute explosive or flammable vapors, fumes, or dusts in accordance with Section 505.9. Hoods of steel shall have a base metal thickness not less than 0.027 of an inch (0.686 mm) (No. 22 gauge) for Class 1 and Class 5 metal duct systems; 0.033 of an inch (0.838 mm) (No. 20 gauge) for hoods serving a Class 2 duct system; 0.044 of an inch (1.118 mm) (No. 18 gauge) for hoods serving a Class 3 duct system; and 0.068 of an inch (1.727 mm) (No. 14 gauge) for hoods serving a Class 4 duct system.

Approved nonmetallic hoods and duct systems shall be permitted to be used for Class 5 corrosive systems where the corrosive mixture is nonflammable. Metal hoods used with Class 5 duct systems shall be protected with an approved corrosion-resistant material. Edges of hoods shall be rounded. The minimum clearance between hoods and combustible construction shall be the clearance required by the duct system.

506.0 Product-Conveying Ducts.

506.1 Materials. Materials used in product-conveying duct systems shall be suitable for the intended use and shall be of metal.

<table>
<thead>
<tr>
<th>NATURE OF CONTAMINANTS</th>
<th>EXAMPLES</th>
<th>FEET PER MINUTE DESIGN VELOCITY (feet per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapors, gases, smoke</td>
<td>Vapors, gases, and smoke</td>
<td>Any</td>
</tr>
<tr>
<td>Fumes</td>
<td>Welding</td>
<td>2000</td>
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<tr>
<td>Fine light dusts</td>
<td>Cotton lint, wood flour, litho powder</td>
<td>2500</td>
</tr>
<tr>
<td>Dry dusts and powders</td>
<td>Fine rubber dust, molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings</td>
<td>3000</td>
</tr>
<tr>
<td>Average industrial dusts</td>
<td>Grinding dust, buffing lint (dry), wool jute dust (shaker waste), coffee beans, shoe dust, granite dust, silica flour, general material handling, brick cutting, clay dust, foundry (general), limestone dust, packaging and weighing asbestos dust in textile industries</td>
<td>3500</td>
</tr>
<tr>
<td>Heavy dusts</td>
<td>Sawdust (heavy and wet), metal turnings, foundry tumbling barrels and shake-out, sandblast dust, wood blocks, hog waste, brass turning, cast-iron boring dust, lead dust</td>
<td>4000</td>
</tr>
<tr>
<td>Heavy or moist dusts</td>
<td>Lead dust with chips, moist cement dust, asbestos chunks from transite pipe cutting machines, buffing lint (sticky), quick-lime dust</td>
<td>4500</td>
</tr>
</tbody>
</table>

For SI units: 1 foot per minute = 0.005 m/s

* Systems that are handling combustible particulate solids shall be in accordance with NFPA 654.
Exceptions:

(1) Asbestos-cement, concrete, clay, or ceramic materials shall be permitted to be used where it is shown that these materials will be equivalent to metal ducts installed in accordance with this chapter.

(2) Ducts serving a Class 5 system shall be permitted to be constructed of approved nonmetallic material where the corrosive characteristics of the material being conveyed make a metal system unsuitable and where the mixture being conveyed is nonflammable.

Approved nonmetallic material shall be either a listed product having a flame-spread index not exceeding 25 and a smoke-developed rating of 50 or less on both inside and outside surfaces without evidence of continued progressive combustion, or shall have a flame-spread index not exceeding 25 and shall be installed with an automatic fire-sprinkler protection system inside the duct.

(3) Ducts used in central vacuum cleaning systems within a dwelling unit shall be constructed of materials in accordance with the applicable standards referenced in Chapter 17. Penetrations of fire walls or floor-ceiling or roof-ceiling assemblies shall be in accordance with the building code.

Copper or ferrous pipes or conduits extending from within the separation between a garage and dwelling unit to the central vacuuming unit shall be permitted to be used.

Aluminum ducts shall not be used in systems conveying flammable vapors, fumes, or explosive dusts, nor in Class 2, 3, or 4 systems. Galvanized steel and aluminum ducts shall not be used where the temperature of the material being conveyed exceeds 400°F (204°C).

Metal ducts used in Class 5 systems that are not resistant to the corrosiveness of the product shall be protected with an approved corrosion-resistant material.

506.2 Construction. Ducts used for conveying products shall be airtight construction as approved by the Authority Having Jurisdiction, and shall not have openings other than those required for operation and maintenance of the system. Ducts constructed of steel shall comply with Table 506.2(1) or Table 506.2(2).

Exceptions:

(1) Class 1 product-conveying ducts that operate at less than 4 inches water column (0.9 kPa) negative pressure and convey noncorrosive, nonflammable and nonexplosive materials at temperatures not exceeding 250°F (121°C) shall be permitted to be constructed in accordance with SMACNA HVAC Duct Construction Standards—Metal and Flexible.

(2) Ducts used in central vacuuming systems within a dwelling unit shall be constructed of materials in accordance with the applicable standards referenced in Chapter 17. Penetrations of fire-resistant walls or floor-ceiling or roof-ceiling assemblies shall be in accordance with the building code. Copper or ferrous pipes or conduit extending from within the separation between a garage and dwelling unit to the central vacuum unit shall be permitted to be used.

The use of rectangular ducts conveying particulates shall be subject to approval of the Authority Having Jurisdiction. The design of rectangular ducts shall consider the adhesiveness and buildup of products being conveyed within the duct.

Aluminum construction shall be permitted to be used in Class 1 duct systems. The thickness of aluminum ducts shall be not less than two Brown and Sharpe gauges thicker than the gauges required for steel ducts set forth in Table 506.2(1) and Table 506.2(2).

506.3 Penetrations. Exhaust ducts shall not pass through fire walls, as defined by NFPA 221. [NFPA 91:4.2.11]

506.3.1 Fire Barriers. Exhaust ducts passing through a fire barrier having a fire resistance rating of 2 hours or more shall meet one of the following specifications:

(1) Wrapped or encased with listed or approved materials having a fire resistance rating equal to the fire barrier for 10 feet (3048 mm) of the duct on each side of the fire barrier including duct supports within this span.

(2) Constructed of materials and supports having a minimum fire resistance rating equal to the fire barrier.

(3) Enclosed with a shaft that is constructed of material having a fire resistance rating equal to the fire barrier for 10 feet (3048 mm) of the duct on each side of the fire barrier with no inlets to the duct within this distance, and the duct entry into and exit from the shaft is protected in accordance with Section 506.3.2. [NFPA 91:4.2.12]

506.3.2 Protection. Exhaust ducts passing through fire barriers of any fire resistance rating shall be protected by sealing the space around the duct with listed or approved fire stopping having a fire resistance rating equal to the fire resistance rating of the fire barrier. [NFPA 91:4.2.13]

506.4 Condensate. Joints in duct construction shall be liquidtight when the conveying system contains condensable vapors or liquids in suspension. [NFPA 91:4.3.6.1]

506.4.1 Drainage. Provisions shall be made for drainage of condensate at low points in the duct. [NFPA 91:4.3.6.2]

506.5 Fittings. Fittings in Class 2, 3, and 4 systems shall be not less than two gauges thicker than the thickness required for straight runs. Flexible metallic duct shall be permitted to be used for connecting ductwork to vibrating equipment. Duct systems subject to wide temperature fluctuations shall be provided with expansion joints.

Branches shall connect to main ducts at the large end of transitions at an angle not exceeding 45 degrees (0.79 rad).

Except for ducts used to convey noncorrosive vapors with no particulate, accessible cleanouts shall be provided at 10 foot (3048 mm) intervals and at changes in direction. Access openings shall also be provided for access to sprinklers and other equipment within the duct that require servicing.

506.6 Explosion Venting. Ducts conveying explosive dusts shall have explosion vents, openings protected by anti-flashback swing valves, or rupture diaphragms. Openings to relieve
<table>
<thead>
<tr>
<th>NEGATIVE PRESSURE (inches water column)</th>
<th>REINF. SPACING (inches)</th>
<th>CLASS 1 (inches)</th>
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<tbody>
<tr>
<td></td>
<td>Up to 7</td>
<td>8 to 11</td>
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<td>12 to 15</td>
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<td>36 to 47</td>
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<td>To 7</td>
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<td>0.127 (10 ga.)</td>
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<td>0.027 (22 ga.)</td>
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<td>0.097 (12 ga.)</td>
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<tr>
<td>16 to 20</td>
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<td>0.021 (24 ga.)</td>
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<td>0.097 (12 ga.)</td>
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<td>8 to 11</td>
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<td>0.021 (24 ga.)</td>
<td>0.027 (22 ga.)</td>
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<td>0.097 (12 ga.)</td>
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<td></td>
<td>0.097 (12 ga.)</td>
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<tr>
<td>12 to 15</td>
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<tr>
<td></td>
<td>0.021 (24 ga.)</td>
<td>0.027 (22 ga.)</td>
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<tr>
<td></td>
<td>0.068 (14 ga.)</td>
<td>0.097 (12 ga.)</td>
</tr>
<tr>
<td></td>
<td>0.097 (12 ga.)</td>
<td>—</td>
</tr>
<tr>
<td>16 to 20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0.021 (24 ga.)</td>
<td>0.027 (22 ga.)</td>
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<td>0.033 (20 ga.)</td>
<td>0.044 (18 ga.)</td>
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<td>0.044 (18 ga.)</td>
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<td>0.055 (16 ga.)</td>
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<td>0.055 (16 ga.)</td>
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<tr>
<td></td>
<td>0.068 (14 ga.)</td>
<td>0.097 (12 ga.)</td>
</tr>
<tr>
<td></td>
<td>0.097 (12 ga.)</td>
<td>—</td>
</tr>
</tbody>
</table>
TABLE 506.2(1) (continued)
MINIMUM SHEET METAL THICKNESS FOR ROUND DUCTS

<table>
<thead>
<tr>
<th>NEGATIVE PRESSURE (inches water column)</th>
<th>REINF. SPACING (inches)</th>
<th>CLASS 3 (inches)</th>
<th>CLASS 4 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 7</td>
<td>8 to 11</td>
<td>12 to 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 to 15</td>
<td>16 to 20</td>
</tr>
<tr>
<td>12 to 15</td>
<td>0.133 (20 ga.)</td>
<td>0.133 (20 ga.)</td>
<td>0.155 (16 ga.)</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>0.133 (20 ga.)</td>
<td>0.144 (18 ga.)</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>0.133 (20 ga.)</td>
<td>0.144 (18 ga.)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>0.133 (20 ga.)</td>
<td>0.144 (18 ga.)</td>
</tr>
<tr>
<td>16 to 20</td>
<td>0.133 (20 ga.)</td>
<td>0.144 (18 ga.)</td>
<td>0.168 (14 ga.)</td>
</tr>
<tr>
<td></td>
<td>96</td>
<td>0.133 (20 ga.)</td>
<td>0.155 (16 ga.)</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>0.133 (20 ga.)</td>
<td>0.144 (18 ga.)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>0.133 (20 ga.)</td>
<td>0.144 (18 ga.)</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 inch water column = 0.249 kPa

Explosive forces shall be located outside the building. Where relief devices cannot provide sufficient pressure relief, ductwork shall be designed to withstand an internal pressure of not less than 100 pounds-force per square inch (psi) (689 kPa).

Where a room or building contains a dust explosion hazard that is external to protected equipment, as defined in NFPA 654, such areas shall be provided with deflagration venting to a safe outside location.

506.7 Supports. Supports shall be of noncombustible materials, and the spacing shall not exceed 12 feet (3658 mm) for 8 inch (203 mm) ducts and 20 feet (6096 mm) for larger ducts.

506.8 Fire Protection. Sprinklers or other fire-protection devices shall be installed within ducts having a cross-sectional dimension exceeding 10 inches (254 mm) where the duct conveys flammable vapors or fumes. Sprinklers shall be installed at 12 foot (3658 mm) intervals in horizontal ducts and at changes in direction. In vertical runs, sprinklers shall be installed at the top and at alternate floor levels.

506.8.1 Loads. Duct supports shall be designed to carry the weight of the duct half filled with material. Where sprinkler protection is provided or cleaning of duct will be performed, the hanger’s design shall include the weight of the expected liquid accumulation. Duct supports shall be designed to prevent placing loads on connected equipment. [NFPA 91:4.6.1 – 4.6.3]

506.8.2 Corrosion. Hangers and supports exposed to corrosive atmospheres shall be corrosion resistant. [NFPA 91:4.6.4]
### TABLE 506.2(2)
MINIMUM SHEET METAL THICKNESS FOR RECTANGULAR DUCTS

<table>
<thead>
<tr>
<th>NEGATIVE PRESSURE (inches water column)</th>
<th>REINF. SPACING (inches)</th>
<th>CLASS 1 (inches)</th>
<th>CLASS 2 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Up to 12</td>
<td>13 to 24</td>
</tr>
<tr>
<td>To 7</td>
<td>48</td>
<td>0.021 (24 ga.)</td>
<td>0.033 (20 ga.)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>0.021 (24 ga.)</td>
<td>0.027 (22 ga.)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.021 (24 ga.)</td>
<td>0.021 (24 ga.)</td>
</tr>
<tr>
<td>8 to 11</td>
<td>48</td>
<td>0.027 (22 ga.)</td>
<td>0.068 (14 ga.)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>0.027 (22 ga.)</td>
<td>0.055 (16 ga.)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.027 (22 ga.)</td>
<td>0.027 (22 ga.)</td>
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<tr>
<td>12 to 15</td>
<td>48</td>
<td>0.044 (18 ga.)</td>
<td>0.097 (12 ga.)</td>
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<td></td>
<td>24</td>
<td>0.044 (18 ga.)</td>
<td>0.055 (16 ga.)</td>
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<td></td>
<td>12</td>
<td>0.044 (18 ga.)</td>
<td>0.044 (18 ga.)</td>
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<tr>
<td>16 to 20</td>
<td>48</td>
<td>0.068 (14 ga.)</td>
<td>0.112 (11 ga.)</td>
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<tr>
<td></td>
<td>24</td>
<td>0.068 (14 ga.)</td>
<td>0.068 (14 ga.)</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.033 (20 ga.)</td>
<td>0.068 (14 ga.)</td>
</tr>
</tbody>
</table>
| CLASS 3 (inches)                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | For SI units: 1 in = 25.4 mm, 1 in of water column = 0.249 kPa
| CLASS 4 (inches)                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.8.3 Vibration and Stress. To prevent vibration and stress on the duct, hangers and supports shall be securely fastened to the building or structure. [NFPA 91:4.6.5]
|                                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.8.4 Expansion and Contraction. Hangers and supports shall be designed to allow for expansion and contraction. [NFPA 91:4.6.6]
|                                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.9 Protection from Physical Damage. Ducts installed in locations where they are subject to physical damage shall be protected by guards.
|                                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.10 Duct Clearances. Unless the conditions in Section 506.10.1 or Section 506.10.2 exist, duct systems and system components shall have a clearance of at least 6 inches (152 mm) from stored combustible materials, and not less than 1/2 of an inch (13 mm) clearance from combustible construction. [NFPA 91:4.7.1]
|                                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.10.1 Protection Provided. Where stored combustible material or combustible construction is protected from ductwork by the use of materials or products listed for protection purposes, clearance shall be maintained in accordance with those listings. [NFPA 91:4.7.1.1]
|                                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.10.2 Systems Conveying Combustible Materials. Unless the conditions in Section 506.10.3 exist, duct systems and system components handling combustible material shall have a clearance of not less than 18 inches (457 mm) from combustible construction or a combustible material. [NFPA 91:4.7.2]
|                                         |                         |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  |                  | 506.10.3 Reduced Clearance Permitted. When the ductwork system is operating at 140°F (60°C) or below and is equipped with an approved automatic extinguishing system designed for the specific hazard, the clear-
506.10.4 Clearance Increases. All duct systems and system components operating at temperatures above 140°F (60°C) shall have clearances from stored combustible materials or combustible construction not less than those listed in Table 506.10.4. [NFPA 91:4.7.3]

### TABLE 506.10.4 BASIC MINIMUM CLEARANCES TO UNPROTECTED SURFACES [NFPA 91: TABLE 4.7.3]

<table>
<thead>
<tr>
<th>DUCT GAS TEMPERATURE</th>
<th>LARGEST DUCT DIMENSION (inches)</th>
<th>CLEARANCE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>140°F – 600°F incl.</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>&gt;8</td>
<td>12</td>
</tr>
<tr>
<td>&gt;600°F – 900°F incl.</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>&gt;8</td>
<td>24</td>
</tr>
<tr>
<td>&gt;900°F</td>
<td>All ducts lined with refractory</td>
<td>24</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, °C=(°F-32)/1.8

506.10.4.1 Temperatures Over 900°F. Ducts handling materials at temperatures in excess of 900°F (482°C) shall be lined with refractory material or the equivalent. [NFPA 91:4.7.3.1]

506.10.4.2 Clearance Reduction. When stored combustible materials or combustible construction are protected from ductwork in accordance with Section 506.11, the clearance established in Table 506.10.4 shall be permitted to be reduced in accordance with Table 506.11, but not to less than specified in Section 506.10. [NFPA 91:4.7.3.2]

506.11 Clearance Reduction Methods. It shall be permitted to protect stored combustible material or combustible construction from ductwork in accordance with Table 506.11 and Section 506.11.1 through Section 506.11.6. In no case shall the clearance between the duct and the combustible surface be reduced below that allowed in Table 506.11. [NFPA 91:4.7.4, 4.7.4.1]

506.11.1 Spacers and Ties. Spacers and ties for protection materials shall be of noncombustible material and shall not be installed on the duct side of the protection system. [NFPA 91:4.7.4.2]

506.11.2 Wool Batts Insulation. Mineral wool batts (blanket or board) shall have a density of not less than 8 pounds per cubic foot (lb/ft3) (128 kg/m3) and have a melting point of not less than 1500°F (816°C). [NFPA 91:4.7.4.3]

506.11.3 Insulation Board. Insulation board used as a part of a clearance-reduction system shall meet the following criteria:

1. Have a thermal conductivity of 1 British thermal unit inch per hour square foot degree Fahrenheit [Btu•in/(hr•ft2•°F)] [0.14 W/(m•K)] or less.
2. Be formed of noncombustible material. [NFPA 91:4.7.4.4]

506.11.4 Duct and Thermal Shield. With all clearance reduction systems, not less than 1 inch (25.4 mm) clear space shall be provided between the duct and the thermal shield. [NFPA 91:4.7.4.5]

506.11.5 Thermal Shield and Combustible Surface. When using clearance reduction systems that include an air gap, not less than 1 inch (25.4 mm) clear space shall be provided between the thermal shield and the combustible surface. [NFPA 91:4.7.4.6]

506.11.6 Reduced Clearance with Air Gaps. When using clearance reduction systems that include an air gap between the combustible surface and the selected means of protection, air circulation shall be permitted to be provided by one of the methods in accordance with Section 506.11.6.1 through Section 506.11.6.2. [NFPA 91:4.7.4.7]

506.11.6.1 Air Circulation. Air circulation shall be permitted to be provided by leaving all edges of the wall protecting system open with at least a 1 inch (25.4 mm) air gap. [NFPA 91:4.7.4.7.1]

506.11.6.2 Single Flat Wall. If the means for protection is mounted on a single flat wall away from corners, air circulation shall be permitted to be provided by one of the following:

1. Leaving only the top and bottom edges open to circulation by maintaining the 1 inch (25.4 mm) air gap.
2. Leaving the top and both side edges open to circulation by maintaining the 1 inch (25.4 mm) air gap. [NFPA 91:4.7.4.7.2]

506.11.6.3 Thermal Shielding. Thermal shielding that covers two walls in a corner shall be permitted to be open at the top and bottom edges with not less than 1 inch (25.4 mm) air gap. [NFPA 91:4.7.4.7.3]

Part II - Commercial Hoods and Kitchen Ventilation.

507.0 General Requirements.

507.1 Type I Hood Exhaust System. Exhaust systems serving Type I hoods shall comply with Section 507.0 through Section 518.0.

507.2 Exhaust System. Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system that is in accordance with all the equipment and performance requirements of this chapter. [NFPA 96:4.1.1] All such equipment and its performance shall be maintained in accordance with the requirements of this chapter during all periods of operation of the cooking equipment. [NFPA 96:4.1.2] The following equipment shall be kept in working condition:

1. Cooking equipment
2. Hoods
3. Ducts (where applicable)
EXHAUST SYSTEMS

TABLE 506.11
REDUCTION OF DUCT CLEARANCE WITH SPECIFIED FORMS OF PROTECTION
[NFPA 91: TABLE 4.7.4]

<table>
<thead>
<tr>
<th>FORM OF PROTECTION*</th>
<th>MAXIMUM ALLOWABLE REDUCTION IN CLEARANCE (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AS WALL PROTECTOR OR VERTICAL SURFACE</td>
</tr>
<tr>
<td>3½ inch thick masonry wall without ventilated air space</td>
<td>33</td>
</tr>
<tr>
<td>½ inch thick noncombustible insulation board over 1 inch glass fiber or mineral wool batts without ventilated air space</td>
<td>50</td>
</tr>
<tr>
<td>0.024 inch (24 gauge) sheet metal over 1 inch glass fiber or mineral wool batts reinforced with wire, or equivalent on rear face with at least a 1 inch air gap</td>
<td>66</td>
</tr>
<tr>
<td>3½ inch (90 mm) thick masonry wall with at least a 1 inch air gap</td>
<td>66</td>
</tr>
<tr>
<td>0.024 inch (24 gauge) sheet metal with at least a 1 inch air gap</td>
<td>66</td>
</tr>
<tr>
<td>½ inch thick noncombustible insulation board with at least a 1 inch air gap</td>
<td>66</td>
</tr>
<tr>
<td>0.024 inch (24 gauge) sheet metal with ventilated air space over at least 0.024 inch (24 gauge) sheet metal with at least a 1 inch air gap</td>
<td>66</td>
</tr>
<tr>
<td>1 inch glass fiber or mineral wool batts sandwiched between two sheets of 0.024 inch (24 gauge) sheet metal with at least a 1 inch air gap</td>
<td>66</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

* Clearance reduction applied to and covering all combustible surfaces within the distance specified as required clearance with no protection in Table 506.10.4.

(4) Fans
(5) Fire-extinguishing equipment
(6) Special effluent or energy control equipment [NFPA 96:4.1.3]

Maintenance and repairs shall be performed on all components at intervals necessary to maintain good working conditions, as follows [NFPA 96:4.1.3.1]

(4) 507.2.1 Airflow. All airflow shall be maintained. [NFPA 96:4.1.4]

(4) 507.2.2 Responsibility. The responsibility for inspection, testing, maintenance, and cleanliness of the ventilation control and fire protection of the commercial cooking operations, including cooking appliances, shall ultimately be that of the owner of the system, provided that this responsibility has not been transferred in written form to a management company, tenant, or other party. [NFPA 96:4.1.5]

(4) 507.2.3 Solid-fuel Cooking Equipment. All solid-fuel cooking equipment shall comply with the requirements of Section 517.0. [NFPA 96:4.1.6]

(4) 507.2.4 Multitenant Applications. Multitenant applications shall require the concerted cooperation of design, installation, operation, and maintenance responsibilities by tenants and by the building owner. [NFPA 96:4.1.7]

(4) 507.2.5 Interior Surfaces. All interior surfaces of the exhaust system shall be accessible for cleaning and inspection purposes. [NFPA 96:4.1.8]

(4) 507.2.6 Used in Other Applications. Cooking equipment used in fixed, mobile, or temporary concessions, such as trucks, buses, trailers, pavilions, tents, or any form of roofed enclosure, shall be in accordance with this chapter unless otherwise exempted by the Authority Having Jurisdiction. [NFPA 96:4.1.9]

507.3 Listed Devices. Penetrations shall be sealed with listed devices in accordance with the requirements of Section 507.3.1.

507.3.1 Penetration. Devices that require penetration of a Type I hood or grease duct, such as pipe and conduit penetration fittings and fasteners, shall be listed in accordance with UL 710 or UL 1978. Seams, joints, and penetrations of the hood enclosure shall comply with Section 508.3.2. Seams, joints, and penetrations of the ductwork shall comply with Section 510.5.3.

507.4 Clearance. Where enclosures are not required, hoods, grease removal devices, exhaust fans, and ducts shall have a clearance of not less than 18 inches (457 mm) to combustible material, 3 inches (76 mm) to limited-combustible material, and 0 inches (0 mm) to noncombustible material. [NFPA 96:4.2.1]

507.4.1 Listed. Where a hood, duct, or grease removal device is listed for clearances less than those in accordance with Section 507.4, the listing requirements shall be permitted. [NFPA 96:4.2.2]

507.4.2 Clearance Reduction. Where a clearance reduction system consisting of 0.013 of an inch (0.33
mm) (28 gauge) sheet metal spaced out 1 inch (25.4 mm) on noncombustible spacers is provided, there shall be not less than 9 inches (229 mm) clearance to combustible material. [NFPA 96:4.2.3.1]

507.4.2.1 Mineral Wool Batts or Ceramic Fiber Blanket. Where a clearance reduction system consisting of 0.027 of an inch (0.686 mm) (22 gauge) sheet metal on 1 inch (25.4 mm) mineral wool batts or ceramic fiber blanket reinforced with wire mesh or equivalent spaced out 1 inch (25.4 mm) on noncombustible spacers is provided, there shall be not less than 3 inches (76 mm) clearance to combustible material. [NFPA 96:4.2.3.2]

507.4.2.2 Field-Applied Grease Duct Enclosure. Where a clearance reduction system consisting of a listed and labeled field-applied grease duct enclosure material, system, product, or method of construction specifically evaluated for such purpose in accordance with ASTM E2336, the required clearance shall be in accordance with the listing. [NFPA 96:4.2.3.3]

507.4.2.3 Zero Clearance. Zero clearance to limited-combustible materials shall be permitted where protected by one of the following:
(1) Metal lath and plaster.
(2) Ceramic tile.
(3) Quarry tile.
(4) Other noncombustible materials or assembly of noncombustible materials that are listed for the purpose of reducing clearance.
(5) Other materials and products that are listed for the purpose of reducing clearance. [NFPA 96:4.2.3.4]

507.4.3 Clearance Integrity. In the event of damage, the material or product shall be repaired and restored to meet its intended listing or clearance requirements and shall be approved by the Authority Having Jurisdiction. [NFPA 96:4.2.4.1]

507.4.3.1 Fire. In the event of a fire within a kitchen exhaust system, the duct and its enclosure (rated shaft, factory-built grease duct enclosure, or field-applied grease duct enclosure) shall be inspected by qualified personnel to determine whether the duct and protection method are structurally sound, capable of maintaining their fire protection function, and in accordance with this chapter for continued operation. [NFPA 96:4.2.4.2]

507.4.3.2 Required Protection. Protection shall be provided on the wall from the bottom of the hood to the floor, or to the top of the noncombustible material extending to the floor, to the same level as required in Section 507.4. [NFPA 96:4.2.4.3]

507.4.3.3 Protection Methods. The protection methods for ducts to reduce clearance shall be applied to the combustible or limited-combustible construction, not to the duct itself. [NFPA 96:4.2.4.4]

507.4.4 Factory Built. Factory-built grease duct enclosures shall be protected with a through-penetration firestop system classified in accordance with ASTM E814 or UL 1479 having an “F” and a “T” rating equal to the fire resistance rating of the assembly being penetrated at the point at which the duct penetrates a ceiling, wall, or floor to the outlet terminal. [NFPA 96:4.3.3]

507.4.4.1 Listing. The factory-built grease duct protection system shall be listed in accordance with UL 2221. [NFPA 96:4.3.3.1]

507.4.4.2 Single Wall. Listed single wall factory-built grease ducts shall be permitted to be enclosed with field-applied grease duct enclosure material where the material and the assembly of duct and material are listed for that application and installed in accordance with the grease duct manufacturer’s listing and their installation instructions. [NFPA 96:4.3.3.2]

507.4.4.3 Installation. The factory-built grease duct protection system shall be installed in accordance with the manufacturer’s installation instructions and the listing requirements. [NFPA 96:4.3.3.3]

507.4.5 Field Applied. Field-applied grease duct enclosures shall be protected with a through-penetration firestop system classified in accordance with ASTM E814 or UL 1479 having an “F” and a “T” rating equal to the fire resistance rating of the assembly being penetrated. The surface of the field fabricated grease duct shall be continuously covered on sides from the point at which the duct enclosure penetrates a ceiling, wall, or floor to the outlet terminal. The field-applied grease duct shall be listed in accordance with ASTM E2336 and installed in accordance with the manufacturer’s installation instructions and the listing requirements. [NFPA 96:4.3.3.4]

507.4.6 Both Field-Applied and Factory Built. Field-applied grease duct enclosures and factory-built grease duct enclosures shall demonstrate that they provide mechanical and structural integrity, resiliency, and stability where subjected to expected building environmental conditions, duct movement under general operating conditions, and duct movement due to fire conditions. [NFPA 96:4.3.4]

507.4.6.1 Physical Damage. Measures shall be taken to prevent physical damage to a material or product used for the purpose of reducing clearances. Exception: Where the duct is protected with a field-applied grease duct enclosure or factory-built grease duct enclosure.

507.4.6.2 Specification. The specifications of material, gauge, and construction of the duct used in the testing and listing of field-applied grease duct enclosures and factory-built grease duct enclosures shall be included as minimum requirements in their listing and installation documentation. [NFPA 96:4.3.5]

507.4.6.3 Clearance Options. The following clearance options for which field-applied grease duct enclosures and factory-built grease duct enclo-
507.4.7 Building and Structural Contact. A duct shall be permitted to contact noncombustible floors, interior walls, and other noncombustible structures or supports, but it shall not be in contact for more than 50 percent of its surface area for each linear foot of contact length. [NFPA 96:4.4.1]

507.4.7.1 Corrosion Protection. Where duct contact must exceed the requirements of Section 507.4.7, the duct shall be protected from corrosion. [NFPA 96:4.4.2]

507.4.7.2 Zero Clearance. Where the duct is listed for zero clearance to combustibles or is otherwise protected with a material or product listed for the purpose of reducing clearance to zero, the duct shall be permitted to exceed the contact limits of Section 507.4.7 without additional corrosion protection. [NFPA 96:4.4.3]

507.4.8 Clearance Between Duct and Interior Surfaces. Clearances between the duct and interior surfaces of enclosures shall be in accordance with the requirements of Section 507.4. [NFPA 96:4.5]

507.5 Drawings. A drawing(s) of the exhaust system installation along with a copy of operating instructions for sub-assemblies and components used in the exhaust system, including electrical schematics, shall be on the premises. [NFPA 96:4.6]

507.6 Notification of Change. Where required by the Authority Having Jurisdiction, notification in writing shall be given of an alteration, replacement, or relocation of an exhaust, extinguishing system or part thereof or cooking equipment. [NFPA 96:4.7]

Satisfaction shall be provided to the Authority Having Jurisdiction that the complete exhaust system as addressed in this chapter is installed and operable in accordance with the approved design and the manufacturer’s installation instructions.

508.0 Type I Hoods.

508.1 Where Required. Type I hoods shall be installed at or above commercial-type deep-fat fryers, broilers, grills, hot-top ranges, ovens, barbecues, rotisseries, and similar equipment that emits comparable amounts of smoke or grease in a food-processing establishment. For the purpose of this section, a food-processing establishment shall include a building or portion thereof used for the processing of food, but shall not include a dwelling unit.

Exceptions:

(1) Cooking appliance that is in accordance with UL 710B for reduced emissions where the grease discharge does not exceed 2.9 E-09 ounces per cubic inch (oz/in³) (5.0 E-06 kg/m³) where operated with a total airflow of 500 cubic feet per minute (cfm) (0.236 m³/s).

(2) Recirculating systems listed in accordance with UL 710B and installed in accordance with Section 516.0.

508.2 Listed Type I Hood Assemblies. Listed hood assemblies shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions. Listed hood assemblies shall be tested in accordance with UL 710 or equivalent. [NFPA 96:5.4.1, 5.4.2]

508.2.1 Listed Ultraviolet Hoods. Listed ultraviolet hoods shall be installed and maintained in accordance with the terms of their listing and the manufacturer’s installation instructions. Duct systems connected to ultraviolet hoods shall comply with Section 510.0. Ultraviolet hoods shall be tested and listed in accordance with UL 710 and UL 710C. [NFPA 96:5.5 – 5.5.2]

508.2.2 Listed Ventilated Ceiling Technology. Listed ventilated ceiling technology shall be installed and maintained in accordance with the terms of its listing and the manufacturer’s instructions. [NFPA 96:5.6]

508.2.2.3 Construction of Listed Exhaust Hoods. Listed exhaust hoods with or without exhaust dampers shall be permitted to be constructed of materials required by the listing. [NFPA 96:5.1.6]

508.2.2.4 Assembly of Listed Exhaust Hoods. Listed exhaust hoods with or without exhaust dampers shall be permitted to be assembled in accordance with the listing requirements. [NFPA 96:5.1.7]

508.3 Construction of Type I Hoods. The hood or that portion of a primary collection means designed for collecting cooking vapors and residues shall be constructed of and be supported by steel that shall not be less than 0.048 of an inch (1.219 mm) (No. 18 MSG), in thickness, stainless steel not less than 0.036 of an inch (0.914 mm) (No. 20 MSG) in thickness, or other approved material of equivalent strength and fire and corrosion resistance. [NFPA 96:5.1.1]

Exception: Listed exhaust hoods.

508.3.1 Grease Vapor. Wall-mounted exhaust hood assemblies shall be tight fitting against the back wall as to not permit passage of grease vapor behind the hood, or between the back wall and the hood assembly. [NFPA 96:5.1.13]

508.3.2 Seams, Joints, and Penetrations. Seams, joints, and penetrations of the hood enclosure that direct and capture grease-laden vapors and exhaust gases shall have a liquid-tight continuous external weld to the hood’s lowermost exterior. [NFPA 96:5.1.2]

Exceptions:

(1) Seams, joints, and penetrations of the hood shall be permitted to be internally welded, provided that the weld is formed smooth or ground smooth, so as not to trap grease, and is cleanable. [NFPA 96:5.1.3]
(2) Penetrations shall be permitted to be sealed by devices that are listed for such use and whose presence does not detract from the hood’s or duct’s structural integrity. [NFPA 96:5.1.5]

508.3.2.1 Sealed. Internal hood joints, seams, filter support frames, and appurtenances attached inside the hood shall be sealed or otherwise made greasetight. [NFPA 96:5.1.4]

508.3.3 Eyebrow-Type Hoods. Eyebrow-type hoods over gas or electric ovens shall be permitted to have a duct constructed as required in Section 510.0 from the oven flue(s) connected to the hood canopy upstream of the exhaust plenum, as shown in Figure 508.3.3. [NFPA 96:5.1.8.1]

508.3.3.1 Duct Connection. The duct connecting the oven flue(s) to the hood canopy shall be connected with a continuous weld or have a duct-to-duct connection. [See Figure 511.1.2(2) through Figure 511.1.2(4)] [NFPA 96:5.1.8.2]

508.3.4 Insulation. Insulation materials other than electrical insulation shall have a flame spread index of not more than 25, where tested in accordance with ASTM E84 or UL 723. Adhesives or cements used in the installation of insulating materials shall be in accordance with this section where tested with the specific insulating material. [NFPA 96:5.1.9, 5.1.10]

508.3.5 Exhaust Hood Assemblies with Integrated Supply-Air Plenums. The construction and size of exhaust hood assemblies with integrated supply air plenums shall be in accordance with the requirements of Section 508.1 through Section 508.5. [NFPA 96:5.3.1]

508.3.5.1 Outer Shell. The construction of the outer shell or the inner exhaust shell shall be in accordance with Section 508.1 through Section 508.3.4. [NFPA 96:5.3.2]

508.3.5.2 Inner Shell. Where the outer shell is welded, the inner shell shall be of greasetight construction. [NFPA 96:5.3.3]

508.3.5.3 Fire Dampers. A fire-actuated damper shall be installed in the supply air plenum at each point where a supply air duct inlet or a supply air outlet penetrates the continuously welded shell of the assembly. [NFPA 96:5.3.4.1]

508.3.5.3.1 Listing. The fire damper shall be listed for such use or be part of a listed exhaust hood with or without exhaust damper. [NFPA 96:5.3.4.2]

508.3.5.3.2 Actuating Temperature. The actuation device shall have a temperature rating not to exceed 286°F (141°C). [NFPA 96:5.3.4.3]

508.3.5.3.3 Exemption. Supply air plenums that discharge air from the face rather than from the bottom or into the exhaust hood and that are isolated from the exhaust hood by the continuously welded shell extending to the lower outermost perimeter of the entire hood assembly shall not require a fire-actuated damper. [NFPA 96:5.3.4.4]

508.4 Supports. Hoods shall be secured in place by non-combustible supports. The supports shall be capable of supporting the expected weight of the hood and plus 800 pounds (362.9 kg).

508.5 Hood Size. Hoods shall be sized in accordance with the airflow capacity in accordance with Section 508.5.1.1 and installed to provide for the removal of heat, and capture and removal of grease-laden vapors in accordance with Section 511.2.2.

508.5.1 Canopy Size and Location. For canopy type commercial cooking hoods, the inside edge thereof shall overhang or extend a horizontal distance of not less than 6 inches (152 mm) beyond the edge of the cooking surface on open sides, and the vertical distance between the lip of the hood and the cooking surface shall not exceed 4 feet (1219 mm).

Exception: Listed exhaust hoods are to be installed in accordance with the terms of their listings and the manufacturer’s installation instructions.

508.5.1.1 Capacity of Hoods. Canopy-type commercial cooking hoods shall exhaust through the hood with a quantity of air not less than determined by the application in accordance with Section 508.1.2 through Section 508.5.1.5. The exhaust quantity shall be the net exhaust from the hood determined in accordance with Equation 508.5.1.1. The duty level for the hood shall be the duty level of the appliance that has the highest (heaviest) duty level of appliances installed underneath the hood.
Exception: Listed exhaust hoods installed in accordance with the manufacturer’s installation instructions.

\[ E_{\text{NET}} = E_{\text{HOOD}} - MA_{\text{ID}} \quad (\text{Equation 508.5.1.1}) \]

Where:
- \( E_{\text{NET}} \) = net hood exhaust
- \( E_{\text{HOOD}} \) = total hood exhaust
- \( MA_{\text{ID}} \) = makeup air, internal discharge

508.5.1.2 Extra-Heavy-Duty Cooking Appliances. The minimum net airflow for hoods used for solid fuel cooking appliances such as charcoal, briquette, and mesquite to provide the heat source for cooking shall be in accordance with Table 508.5.1.2.

**TABLE 508.5.1.2**

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>AIRFLOW (cubic foot per minute per linear foot of hood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>550</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>700</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>550</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 foot = 304.8 mm

508.5.1.3 Heavy-Duty Cooking Appliances. The minimum net airflow for hoods used for cooking appliances such as gas under-fired broilers, gas chain (conveyor) broilers, electric and gas wok ranges, and electric and gas over-fired (upright) broilers shall be in accordance with Table 508.5.1.3.

**TABLE 508.5.1.3**

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>AIRFLOW (cubic foot per minute per linear foot of hood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>400</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>400</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>600</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>400</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 foot = 304.8 mm

508.5.1.4 Medium-Duty Cooking Appliances. The minimum net airflow for hoods used for cooking appliances such as electric and gas hot-top ranges, gas open-burner ranges (with or without oven), electric and gas flat griddles, electric and gas double-sided griddles, electric and gas fryers (including open deep fat fryers, donut fryers, kettle fryers, and pressure fryers), and electric and gas conveyor pizza ovens shall be in accordance with Table 508.5.1.4.

**TABLE 508.5.1.4**

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>AIRFLOW (cubic foot per minute per linear foot of hood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>300</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>300</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>250</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>500</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>300</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 foot = 304.8 mm

508.5.1.5 Light-Duty Cooking Appliances. The minimum net airflow for hoods used for cooking appliances such as gas and electric ovens (including standard, bake, roasting, revolving, retherm, convection, combination convection/steamer, rotisserie, countertop conveyorized baking/finishing, deck, and pastry), discrete element ranges (with or without oven), electric and gas steam-jacketed kettles less than 20 gallons (76 L), electric and gas pasta cookers, electric and gas compartment steamer (both pressure and atmospheric), electric and gas cheese melters, electric and gas tilting skillets (braising pans) electric and gas rotisseries, and electric and gas salamanders shall be in accordance with Table 508.5.1.5.

**TABLE 508.5.1.5**

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>AIRFLOW (cubic foot per minute per linear foot of hood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backshelf/pass-over</td>
<td>250</td>
</tr>
<tr>
<td>Double island canopy (per side)</td>
<td>250</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>Not permitted</td>
</tr>
<tr>
<td>Single island canopy</td>
<td>400</td>
</tr>
<tr>
<td>Wall-mounted canopy</td>
<td>200</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 foot = 304.8 mm

508.5.2 Noncanopy-Type Hoods. Noncanopy-type commercial cooking hoods shall be installed and sized in accordance with the manufacturer’s installation instructions, and Sections 508.5.2.1 and 508.5.2.2. Exception: Listed hood assemblies designed and installed specifically for the intended use.

508.5.2.1 Installation. Noncanopy-type commercial cooking hoods shall be installed with the edge of the hood set back not more than 1 foot (305 mm) from the edge of the cooking surface, and the vertical distance between the lip of the hood and the cooking surface shall not exceed 3 feet (914 mm).
508.5.2.2 Capacity. In addition to other requirements for hoods specified in this section, the volume of air exhausting through a noncanopy-type hood to the duct system shall be not less than 300 cubic feet per minute per lineal foot [(ft^3/min)/ft] [0.464 (m^3/s)/m] of cooking equipment. Listed noncanopy exhaust hoods and filters shall be sized and installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

508.5.3 Labeling. Type I hoods shall bear a label indicating the exhaust flow rate in cubic feet per minute per lineal foot [(m^3/s)/m].

508.6 Solid-Fuel Hood Assemblies. Where solid-fuel cooking equipment is to be used, the solid-fuel hood assembly shall be in accordance with Section 517.0.

508.7 Exhaust Outlets. An exhaust outlet within an unlisted hood shall be located so as to optimize the capture of particulate matter. Each outlet shall serve not more than a 12 foot (3658 mm) section of an unlisted hood.

509.0 Grease Removal Devices in Hoods.

509.1 Grease Removal Devices. Listed grease filters or other listed grease removal devices intended for use with commercial cooking operations shall be provided. Listed grease filters and grease removal devices that are removable, but not an integral component of a specific listed exhaust hood, shall be listed in accordance with UL 1046 and shall be designated on the filter. [NFPA 96:6.1.1, 6.1.2]

509.2 Installation. The distance between the grease removal device and the cooking surface shall be not less than 18 inches (457 mm). [NFPA 96:6.2.1.1]

509.2.1 Vertical Distance. Where grease removal devices are used in conjunction with charcoal solid fuel or charcoal solid fuel-type broilers, including gas or electrically heated charbroilers, a minimum vertical distance of not less than 4 feet (1219 mm) shall be maintained between the lower edge of the grease removal device and the cooking surface. [NFPA 96:6.2.1.1]

Exceptions:

1. For cooking equipment without exposed flame and where flue gases bypass grease removal devices, the minimum vertical distance shall be permitted to be reduced to not less than 6 inches (152 mm). [NFPA 96:6.2.1.3]

2. Where a grease removal device is listed for separation distances less than those required in Section 509.2 and Section 509.2.1, the listing requirements shall be permitted. [NFPA 96:6.2.1.4]

3. Grease removal devices supplied as part of listed hood assemblies shall be installed in accordance with the terms of the listing and the manufacturer’s installation instructions. [NFPA 96:6.2.1.5]

509.2.2 Grease Removal Device Protection. Where the distance between the grease removal device and the appliance flue outlet (heat source) is less than 18 inches (457 mm), grease removal devices shall be protected from combustion gas outlets and from direct flame impingement occurring during normal operation of cooking appliances producing high flue gas temperatures. [NFPA 96:6.2.2.1]

509.2.2.1 Installation. This protection shall be permitted to be accomplished by the installation of a steel or stainless steel baffle plate between the heat source and the grease removal device. [NFPA 96:6.2.2.2]

509.2.2.2 Size and Location. The baffle plate shall be sized and located so that flames or combustion gases shall travel a distance not less than 18 inches (457 mm) from the heat source to the grease removal device. [NFPA 96:6.2.2.3]

509.2.2.3 Clearance. The baffle shall be located not less than 6 inches (152 mm) from the grease removal devices. [NFPA 96:6.2.2.4]

509.2.3 Grease Filters. Grease filters shall be listed and constructed of steel or other non-combustible material, and shall be of rigid construction that will not distort or crush under normal operation, handling, cleaning, or replacement.

509.2.3.1 Arrangement. Grease filters shall be arranged so that all exhaust air passes through the grease filters. [NFPA 96:6.2.3.4]

509.2.3.2 Accessibility. Grease filters shall be easily accessible for removal. [NFPA 96:6.2.3.5]

509.2.3.3 Angled Installation. Grease filters shall be installed at an angle not less than 45 degrees (0.79 rad) from the horizontal. [NFPA 96:6.2.3.6]

509.2.4 Grease Drip Trays. Grease filters shall be equipped with a grease drip tray beneath their lower edges. [NFPA 96:6.2.4.1]

509.2.4.1 Size and Pitch. Grease drip trays shall be kept to the minimum size needed to collect grease. Grease drip trays shall be pitched to drain into an enclosed metal container having a capacity not exceeding 1 gallon (4 L). [NFPA 96:6.2.4.2, 6.2.4.3]

509.2.5 Grease Filter Orientation. Grease filters that require a specific orientation to drain grease shall be clearly so designated on the face of the filter as to be visible with the filter installed, or the hood or filter shall be constructed so that filters cannot be installed in the wrong orientation. [NFPA 96:6.2.5]

509.3 Solid-Fuel Grease Removal Devices. Where solid-fuel cooking equipment is provided with grease removal devices, these devices shall be in accordance with Section 517.0.

510.0 Exhaust Duct Systems.

510.1 General. Ducts shall not pass through fire walls. [NFPA 96:7.1.1]
510.1.1 Fire Hazards. Ducts shall lead as directly to the exterior of the building, so as not to unduly increase a fire hazard. [NFPA 96:7.1.2]

510.1.2 Interconnection. Duct systems shall not be interconnected with any other building ventilation or exhaust system. [NFPA 96:7.1.3]

510.1.3 Duct Installation. All ducts shall be installed with not less than a minimum 2 percent slope on horizontal runs up to 75 feet (22 860 mm) and not less than a minimum 8 percent slope on horizontal runs greater than 75 feet (22 860 mm). Factory-built grease ducts shall be permitted to be installed at a lesser slope in accordance with the listing and the manufacturer’s installation instructions. All horizontal ducts shall be provided with access in accordance with Section 510.3.3.

Drains shall be provided at low points in horizontal ducts. Where provided, drains shall be continuously welded to the exhaust duct or listed grease duct drains in accordance with the terms of the listing and the manufacturer’s installation instructions.

All ducts shall be installed without forming dips or traps. In manifold (common duct) systems, the lowest end of the main duct shall be connected flush on the bottom with the branch duct. [NFPA 96:7.1.4 – 7.1.4.5]

510.1.4 Accessibility. Openings required for accessibility shall be in accordance with Section 510.3 through Section 510.3.2. [NFPA 96:7.1.5]

510.1.5 Sign. A sign stating the following shall be placed on all access panels stating the following: ACCESS PANEL – DO NOT OBSTRUCT [NFPA 96:7.1.6]

510.1.6 Bracing and Supports. Duct bracing and supports shall be of noncombustible material, securely attached to the structure and designed to carry gravity and lateral loads within the stress limitations of the building code. Bolts, screws, rivets, and other mechanical fasteners shall not penetrate duct walls.

510.1.7 Type I Exhaust Duct Systems. Listed grease ducts shall be installed in accordance with the terms of their listings and manufacturer’s installation instructions. [NFPA 96:7.1.7]

510.2 Clearance. Clearance between ducts and combustible materials shall be provided in accordance with the requirements of Section 507.4. [NFPA 96:7.2]

510.3 Openings. Openings shall be provided at the sides or at the top of the duct, whichever is more accessible, and at changes of direction. Openings shall be protected by approved access constructed and installed in accordance with the requirements of Section 510.3.7. [NFPA 96:7.3.1, 7.3.2] Exception: Openings shall not be required in portions of the duct that are accessible from the duct entrance or discharge. [NFPA 96:7.3.3]

510.3.1 Access Panel. For hoods with dampers in the exhaust or supply collar, an access panel for cleaning and inspection shall be provided in the duct or the hood within 18 inches (457 mm) of the damper. [NFPA 96:7.3.4]

510.3.2 Access for Cleaning and Inspection. Exhaust fans with ductwork connected to both sides shall have access for cleaning and inspection within 3 feet (914 mm) of each side of the fan. Wall-mounted exhaust fans shall have access for cleaning and inspection within 3 feet (914 mm) of the exhaust fan. [NFPA 96:7.3.7, 7.3.8]

510.3.3 Horizontal Ducts. On horizontal ducts, not less than at least one 20 inch by 20 inch (508 mm by 508 mm) opening shall be provided for personnel entry. [NFPA 96:7.4.1.1]

510.3.3.1 Cleaning. Where an opening of the size specified in Section 510.3.3 is not possible, openings large enough to permit thorough cleaning shall be provided at 12 feet (3658 mm) intervals. [NFPA 96:7.4.1.2]

510.3.3.2 Safe Access and Work Platform. Where not easily accessible from a 10 foot (3048 mm) stepladder, openings on horizontal grease duct systems shall be provided with safe access and a work platform. [NFPA 96:7.4.1.3]

510.3.3.3 Support. Support systems for horizontal grease duct systems 24 inches (610 mm) and larger in a cross-sectional dimension shall be designed for the weight of the ductwork plus 800 pounds (362.9 kg) at a point in the duct systems. [NFPA 96:7.4.1.4]

510.3.4 Vertical Ducts. On vertical ductwork where personnel entry is possible, access shall be provided at the top of the vertical riser to accommodate descent. [NFPA 96:7.4.2.1]

510.3.4.1 Access. Where personnel entry is not possible, an access for cleaning shall be provided on each floor. [NFPA 96:7.4.2.2]

510.3.4.2 Safe Access and Work Platform. Where not easily accessible from the floor or a 10 foot (3048 mm) stepladder, openings on vertical grease ducts shall be provided with safe access and a work platform. [NFPA 96:7.4.2.3]

510.3.5 Nonlisted Ductwork. On nonlisted ductwork, the edge of the opening shall be not less than 1½ inches (38 mm) from all outside edges of the duct or welded seams. [NFPA 96:7.4.1.5]

510.3.6 Access Panels. Access panels shall be of the same material and thickness as the duct. Access panels shall have a gasket or sealant that is rated for 1500°F (816°C) and shall be greasestight. Fasteners, such as bolts, weld studs, latches, or wing nuts, used to secure the access panels shall be carbon steel or stainless steel and shall not penetrate duct walls. [NFPA 96:7.4.3.1 – 7.4.3.3]

Exception: 510.3.6.1 Listed Grease Ducts. Listed grease duct access door assemblies (access panels) shall be installed in accordance with the terms of the listings and the manufacturer’s installation instructions. [NFPA 96:7.4.3.4]
510.5.4 Butt Welded Connections. Butt welded connections shall not be permitted. [NFPA 96:7.5.5.2]

510.5.5 Telescoping and Bell-Type Connections. For telescoping and bell-type connections, the inside duct section shall always be uphill of the outside duct section. [NFPA 96:7.5.5.3] The overlap shall not exceed 2 inches (51 mm) as shown in Figure 510.5.3.2(1).

510.5.6 Duct Leakage Test. Prior to the use of or concealment of a grease duct system, a leakage test shall be performed to determine that welded joints and seams are liquid tight. The leakage test shall consist of a light test, water pressure test, or an approved equivalent test. The permit holder shall be responsible for providing the necessary equipment and for performing the test. Such test shall be conducted in accordance with ASHRAE 154.

510.6 Exterior Installations. The exterior portion of the ductwork shall be vertical wherever possible and shall be installed and supported on the exterior of a building. Bolts, screws, rivets, and other mechanical fasteners shall not penetrate duct walls. Clearance of a duct shall be in accordance with Section 507.4. [NFPA 96:7.6.1 – 7.6.3]

510.6.1 Weather Protection. Ducts shall be protected on the exterior by paint or other suitable weather-protective coating. Ducts constructed of stainless steel shall not be required to have additional paint or weather-protective coatings. Ductwork subject to corrosion shall have minimal contact with the building surface. [NFPA 96:7.6.4 – 7.6.6]

510.7 Interior Installations. In all buildings more than one story in height, and in one-story buildings where the roof-ceiling assembly is required to have a fire resistance rating, the ducts shall be enclosed in a continuous enclosure extending from the lowest fire-rated ceiling or floor above the hood, through any concealed spaces, to or through the roof, to maintain the integrity of the fire separations required by the applicable building code provisions. The enclosure shall be sealed around the duct at the point of penetration of the first fire-rated barrier after the hood, to maintain the fire resistance rating of the enclosure. The enclosure shall be vented to the exterior of the building through weather-protected openings. [NFPA 96:7.7.1.2 – 7.7.1.4]

Exception: The continuous enclosure provisions shall not be required where a field-applied grease duct enclosure or a factory-built grease duct enclosure (see Section 507.4.4 through Section 507.4.6) is protected with a listed duct-through-penetration protection system equivalent to the fire resistance rating of the assembly being penetrated, and where the materials are installed in accordance with the conditions of the listings.

510.5.3.2 Welded Duct Connection. Duct-to-duct connection shall be as follows:
(1) Telescoping joint, as shown in Figure 510.5.3.2(1).
(2) Bell-type joint, as shown in Figure 510.5.3.2(2).
(3) Flange with edge weld, as shown in Figure 510.5.3.2(3).
(4) Flange with filled weld, as shown in Figure 510.5.3.2(4). [NFPA 96:7.5.5.1]

510.5.3 Welded Duct Connection. Duct-to-duct connection shall be as follows:
(1) Telescoping joint, as shown in Figure 510.5.3.2(1).
(2) Bell-type joint, as shown in Figure 510.5.3.2(2).
(3) Flange with edge weld, as shown in Figure 510.5.3.2(3).
(4) Flange with filled weld, as shown in Figure 510.5.3.2(4). [NFPA 96:7.5.5.1]

510.4 Listed Grease Ducts. Listed grease ducts shall be installed in accordance with the terms of the listing and the manufacturer’s installation instructions. [NFPA 96:7.1.7]

510.4.1 Factory-Built Grease Ducts. Factory-built grease ducts in accordance with UL 1978 shall be permitted to incorporate non-welded joints in accordance with their listings.

510.5 Other Grease Ducts. Other grease ducts shall comply with the requirements of Section 510.5.1 through Section 510.5.5. [NFPA 96:7.5]

510.5.1 Materials. Ducts shall be constructed of and supported by carbon steel not less than 0.060 of an inch (1.524 mm) (No. 16 MSG) in thickness or stainless steel not less than 0.048 of an inch (1.219 mm) (No. 18 MSG) in thickness. [NFPA 96:7.5.1.1]

510.5.2 Factory-Built Grease Ducts. Factory-built grease ducts listed in accordance with UL 1978 shall be permitted to use materials in accordance with their listing. [NFPA 96:7.5.1.2]

510.5.3 Installation. Seams, joints, penetrations, and duct-to-hood collar connections shall have a liquid-tight continuous external weld. [NFPA 96:7.5.2.1]

Exceptions:
(1) Factory-built grease duct listed in accordance with UL 1978 shall be permitted to incorporate non-welded joint construction in accordance with their listing. [NFPA 96:7.5.2.1.1]
(2) Duct-to-hood collar connections as shown in Figure 510.5.3 shall not require a liquid-tight continuous external weld. [NFPA 96:7.5.2.2]
(3) Penetrations shall be permitted to be sealed by other listed devices that are tested to be grease tight and are evaluated under the same conditions of fire severity as the hood or enclosure of listed grease extractors and whose presence does not detract from the hood’s or the duct’s structural integrity. [NFPA 96:7.5.2.3]
(4) Internal welding shall be permitted, provided the joint is formed or ground smooth and is readily accessible for inspection. [NFPA 96:7.5.2.4]

510.5.3.1 Duct Leakage Test. Prior to the use of or concealment of a portion of a grease duct system, a leakage test shall be performed to determine that all welded joints and seams are liquid tight. [NFPA 96:7.5.2.1.2]
FIGURE 510.5.3
PERMITTED DUCT-TO HOOD COLLAR CONNECTION
[NFPA 96: FIGURE 7.5.2.2]

Notes:
1. Duct size decreases (going upward) with each telescope.
2. Smaller (inside) duct section shall be above or uphill (on sloped duct),
   to be self draining into larger (outside) duct.

FIGURE 510.5.3.2(1)
TELESCOPING -TYPE DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(a)]

FIGURE 510.5.3.2(2)
BELL-TYPE DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(b)]

FIGURE 510.5.3.2(3)
FLANGE WITH EDGE WELD DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(c)]

FIGURE 510.5.3.2(4)
FLANGE WITH FILLED WELD DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(d)]
and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.1.5]

510.7.1 Less than Four Stories. Buildings less than four stories in height shall have an enclosure with a fire resistance rating of not less than 1 hour. [NFPA 96:7.7.2.1.1]

510.7.2 Four Stories or More. Buildings four stories or more in height shall have an enclosure with a fire resistance rating of not less than 2 hours. [NFPA 96:7.7.2.1.2]

510.7.3 Clearance. Clearance from the duct or the exhaust fan to the interior surface of enclosures of combustible construction shall be not less than 18 inches (457 mm); and Clearance from the duct to the interior surface of enclosures of noncombustible or limited-combustible construction shall be not less than 6 inches (152 mm). Provisions for reducing clearances as described in Section 507.4 through Section 507.4.3.3 shall not be applicable to enclosures. [NFPA 96:7.7.2.1.2 – 7.7.2.2.3]

Exception: Clearance from the outer surfaces of field-applied grease duct enclosures and factory-built grease duct enclosures to the interior surfaces of construction installed around them shall be permitted to be reduced where the field-applied grease duct enclosure materials and the factory-built grease duct enclosures are installed in accordance with the conditions of the listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.2.2.4]

510.7.4 Mechanical and Structural Integrity. Field-applied grease duct enclosures and factory-built grease duct enclosures shall provide mechanical and structural integrity, resiliency, and stability where subjected to expected building environmental conditions, duct movement under general operating conditions, and duct movement as a result of interior and exterior fire conditions. [NFPA 96:7.7.2.2.5]

510.7.5 Materials. For field-applied grease duct enclosures and factory-built grease duct enclosures, the materials and products shall be provided in accordance with Section 510.7.5.1 and Section 510.7.5.2.

510.7.5.1 Protection from Physical Damage. Measures shall be taken to prevent physical damage to any covering or enclosure material. Damage to the covering or enclosure shall be repaired, and the covering or enclosure shall be restored in accordance with the intended listing and fire-resistance ratings and to be acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.1, 7.7.3.2]

510.7.5.2 Inspection. In the event of a fire within a kitchen exhaust system, the duct, the enclosure, and the covering directly applied to the duct shall be inspected by qualified personnel to determine whether the duct, the enclosure, and the covering directly applied to the duct are structurally sound, capable of maintaining their fire protection functions, approved suitable for continued operation, and acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.3]

510.7.6 Listed. For listed grease ducts, see Section 510.4.

510.7.7 Fire Doors. Where openings in the enclosure walls are provided, they shall be protected by listed fire doors of proper rating. Fire doors shall be installed in accordance with NFPA 80. Openings on other listed materials or products shall be clearly identified and labeled according to the terms of the listing and the manufacturer’s instructions and shall be acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.4.1 – 7.7.4.3] The fire door shall be readily accessible, aligned, and of sufficient size to allow access to the rated access panels on the ductwork. [NFPA 96:7.7.4.4]

510.7.8 Ducts with Enclosure(s). Each duct system shall constitute an individual system serving only exhaust hoods in one fire zone on one floor. Multiple ducts shall not be permitted in a single enclosure unless acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.5 – 7.7.5.2]

510.8 Underground Installations. Grease ducts installed underground shall be approved for underground installation. The material of the grease duct shall be corrosion-resistant and shall comply with Section 510.5.1.

510.8.1 Grease Receptacle. The grease duct shall be sloped to drain the grease back to an approved grease collection device. A grease collection device shall be located at the base of the vertical riser.

510.8.2 Cleanouts. For horizontal installations, cleanouts for cleaning and maintenance shall be provided on the top portion of the grease duct in accordance with Section 510.3 and shall be labeled at the interior portion of the duct.

510.9 Termination of Type I Hood Exhaust System. The exhaust system shall terminate as follows:

1. Outside the building with a fan or duct.
2. Through the roof or to the roof from outside in accordance with Section 510.9.1, or through a wall in accordance with Section 510.9.2. [NFPA 96:7.8.1]

510.9.1 Rooftop Terminations. Rooftop terminations shall be arranged with or provided with the following:

1. Not less than A minimum of 10 feet (3048 mm) of horizontal clearance from the outlet to adjacent buildings, property lines, and air intakes.
2. Not less than A minimum of 5 feet (1524 mm) of horizontal clearance from the outlet (fan housing) to any combustible structure.
3. A vertical separation of 3 feet (914 mm) below any exhaust outlet for above any air intakes within 10 feet (3048 mm) of the exhaust outlet.
4. The ability to drain grease out of traps or low points formed in the fan or duct near the termination of the system into a collection container that is noncombustible, closed, rainproof, and structurally sound for the service to which it is applied, and that will not sustain combustion.
A grease collection device that is applied to exhaust systems that does not inhibit the performance of any fan.

A listed grease collection systems that is in accordance with meet the requirements of Section 510.9.1(4) and Section 510.9.1(5).

A listed grease duct in accordance complying with Section 507.4.7 or ductwork in accordance complying with Section 507.4.8.

A hinged upblast fan supplied with flexible weatherproof electrical cable and service hold-open retainers to permit inspection and cleaning that is listed for commercial cooking equipment with the following conditions:

(a) Where the fan attaches to the ductwork, the ductwork is not less than a minimum of 18 inches (457 mm) away from the roof surface, as shown in Figure 510.9.1.

(b) The fan discharges not less than a minimum of 40 inches (1016 mm) away from the roof surface, as shown in Figure 510.9.1.

Other approved fan, provided it is in accordance with meets all of the following criteria:

(a) The fan is in accordance with meets the requirements of Section 510.9.1(3) and Section 511.1.3.

(b) Its discharge or its extended duct discharge is in accordance with meets the requirements of Section 510.9.1(2). (See Section 511.1.3)

(c) Exhaust fan discharge is directed up and away from the roof surface. [NFPA 96:7.8.2.1]

**510.9.1.2 Inspection and Cleaning.** Fans shall be provided with safe access and a work surface for inspection and cleaning. [NFPA 96:7.8.2.2]

**510.9.2 Wall Terminations.** Wall terminations shall be arranged with or provided with the following properties:

(1) Through a noncombustible wall with not less than 10 feet (3048 mm) of clearance from the outlet to adjacent buildings, property lines, grade level, combustible construction, electrical equipment or lines, and the closest point of an air intake or operable door or window at or below the plane of the exhaust termination. The closest point of an air intake or operable door or window above the plane of the exhaust termination shall be not less than 10 feet (3048 mm) in distance, plus 3 inches (76 mm) for each 1 degree (0.017 rad) from horizontal, the angle of degree being measured from the center of the exhaust termination to the center of the air intake, operable door or window, as indicated in Figure 510.9.2.

**Exception:** A wall termination in a secured area shall be permitted to be at a lower height above grade where acceptable to the Authority Having Jurisdiction.

(2) The exhaust flow shall be directed perpendicularly outward from the wall face or upward.

(3) The ductwork shall be pitched to drain the grease back into the hood(s) or with a drain provided to bring the grease back into a container within the building or into a remote grease trap.

(4) A listed grease duct shall comply with Section 510.3.3 through Section 510.3.7; other ducts shall comply with Section 510.5.

(5) An approved fan shall comply with the requirements of Section 510.9.2(3), and Section 511.1.1 or Section 511.1.3. [NFPA 96:7.8.3]

**510.10 Solid-Fuel Duct Systems.** Where solid-fuel cooking equipment is to be vented, the duct system shall be in accordance with Section 517.0.

**511.0 Air Movement.**

**511.1 Exhaust Fans for Commercial Cooking Operations.** Exhaust fans shall be installed in accordance with Section 511.1.1 through Section 511.1.6. Exhaust fans shall comply with UL 762 and be installed in accordance with the manufacturer’s installation instructions.

**511.1.1 Upblast Fans.** Upblast fans with motors surrounded by the airstream shall be hinged and supplied with flexible weatherproof electrical cable, and service hold-open retainers. Installation shall comply with the requirements of Section 510.9. Upblast fans shall have a drain directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L). [NFPA 96:8.1.2]

**511.1.2 In-Line Exhaust Fans.** In-line fans shall be of the type with the motor located outside the airstream and with belts and pulleys protected from the airstream by a greasetight housing. In-line fans shall be connected to the exhaust duct by flanges securely bolted as shown.
in Figure 511.1.2(1) through Figure 511.1.2(4), or by a system specifically listed for such use. Flexible connectors shall not be used. [NFPA 96:8.1.3.1 – 8.1.3.3]

511.1.2.1 Accessibility. Where the design or positioning of the fan allows grease to be trapped, a drain directed to a readily accessible and visible grease receptacle, not exceeding 1 gallon (4 L), shall be provided. In-line exhaust fans shall be located in easily accessible areas of approved adequate size to allow for service or removal. Where the duct system connected to the fan is in an enclosure, the space or room in which the exhaust fan is located shall have the same fire resistance rating as the enclosure. [NFPA 96:8.1.3.4 – 8.1.3.6]

511.1.3 Utility Set Exhaust Fans. Utility set exhaust fans shall be installed in accordance with Section 511.1.3.1 through Section 511.1.3.3.

511.1.3.1 At the Rooftop. Fans installed at the rooftop termination point shall be in accordance with the following:
(1) Section 510.9.1 and Section 510.9.1.2.
(2) Flexible connectors shall be permitted.
(3) A drain shall be directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L).

511.1.3.2 Within the Building. Fans installed within the building shall be in accordance with the following:
(1) Located in an accessible area of a size to allow for service or removal. [NFPA 96:8.1.4.2]
(2) Flexible connectors shall be prohibited. [NFPA 96:8.1.4.5]
(3) A drain shall be directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L). [NFPA 96:8.1.4.6]
**511.1.3.3 Duct Systems.** Duct systems connected to fans in an enclosure shall be in accordance with the following:

1. The space or room in which the exhaust fan is located shall have the same fire resistance rating as the enclosure.
2. The fan shall be connected to the exhaust duct by flanges securely bolted as shown in Figure 511.1.2(1) through Figure 511.1.2(4) or by a system specifically listed for such use. [NFPA 96:8.1.4.3, 8.1.4.4]

**511.1.4 Construction.** Exhaust fan housings shall be constructed of carbon steel not less than 0.060 of an inch (1.524 mm) (No. 16 MSG) in thickness, of stainless steel not less than 0.048 of an inch (1.219 mm) (No. 18 MSG) in thickness, or, where listed, in accordance with the terms of the listing. [NFPA 96:8.1.5]

**511.1.5 Openings.** Openings for cleaning, servicing, and inspection shall be in accordance with the requirements of Section 510.3.2. Clearances shall be in accordance with the requirements of Section 507.4, or Section 510.7.3 and Section 510.7.4 where installed within an enclosure. [NFPA 96:8.1.6.1, 8.1.6.2]
511.1.6 Standard. Wiring and electrical equipment shall comply with NFPA 70. [NFPA 96:8.1.7]

511.2 Airflow. The air velocity through a duct shall be not less than 500 feet per minute (ft/min) (2.54 m/s) and not exceed 2500 ft/min (12.7 m/s).

511.2.1 Exceptions. Transition duct sections that do not exceed 3 feet (914 mm) in length and do not contain grease traps shall be permitted to be connected to hoods and exhaust fans that do not meet this velocity. [NFPA 96:8.2.1.2]

511.2.2 Exhaust-Air Volumes. Exhaust air volumes for hoods shall be of sufficient level to provide for capture and removal of grease-laden cooking vapors. Test data, performance tests approved by the Authority Having Jurisdiction, or both shall be displayed, provided on request, or both. [NFPA 96:8.2.2.1, 8.2.2.2] Lower exhaust air volumes shall be permitted during no-load and partial load cooking conditions, provided they are sufficient to capture and remove flue gases and cooking effluent from cooking equipment.

511.2.2.1 Performance Test. A performance test shall be conducted upon completion and before final approval of the installation of a ventilation system serving commercial cooking appliances. The test shall verify the rate of exhaust airflow in accordance with Section 508.5.1.2 through Section 508.5.1.5. The permit holder shall furnish the necessary test equipment and devices required to perform the tests. [ASHRAE 154:4.7.1]

511.2.2.2 Capture and Containment Test. The permit holder shall verify the capture and containment performance of Type I hoods. A field test shall be conducted with all appliances under the hood at operating temperatures, all the hoods operating at design airflows, and with all sources of replacement air operating at design airflow for the restaurant. Capture and containment shall be verified visually by observing smoke or steam produced by actual cooking operation or by simulating cooking using devices such as smoke candles or smoke puffers. Smoke bombs shall not be used. [ASHRAE 154:4.7.2]

511.2.3 Exhaust Fan Operation. A hood exhaust fan(s) shall continue to operate after the extinguishing system has been activated, unless fan shutdown is required by a listed component of the ventilation system, or by the design of the extinguishing system. The hood exhaust fan shall not be required to start upon activation of the extinguishing system unless the exhaust fan and all cooking equipment served by the fan have been shut down. Fan shutdown is required by a listed component of the ventilation system or by the listing of the extinguishing system. The exhaust fan shall be provided with a means so that the fan is activated when any heat-producing cooking appliance under the hood is turned on. [NFPA 96:8.2.3.1 – 8.2.3.3]

511.3 Makeup Air. The makeup air quantity shall prevent negative pressures in the commercial cooking area(s) from exceeding 0.02 inch water column (0.005 kPa). Where the fire-extinguishing system activates, makeup air supplied internally to a hood shall be shut off.

For compensating hoods, where a Type I or Type II hood has an internal discharge of makeup air, the makeup airflow shall not exceed 10 percent of the exhaust airflow, the exhaust airflow shall be the net exhaust from the hood in accordance with Section 508.5.1.2 through Section 508.5.1.5. The total hood exhaust shall be determined in accordance with Equation 511.3.

\[ E_{\text{NET}} = E_{\text{HOOD}} - MA_{\text{ID}} \]

(Equation 511.3)

Where:
- \( E_{\text{NET}} \) = net hood exhaust
- \( E_{\text{HOOD}} \) = total hood exhaust
- \( MA_{\text{ID}} \) = makeup air, internal discharge

511.3.1 Air Balance. Design plans for a facility with a commercial kitchen ventilation system shall include a schedule or diagram indicating the design outdoor air balance. The design outdoor air balance shall indicate the exhaust and replacement air for the facility and the net exfiltration where applicable. The total replacement airflow rate shall equal the total exhaust airflow rate and the net exfiltration.

511.4 Common Duct (Manifold) Systems. Master kitchen exhaust ducts that serve multiple tenants shall include provision to bleed air from outdoors or from adjacent spaces into the master exhaust duct where required to maintain the necessary minimum air velocity in the master exhaust duct. [NFPA 96:8.4.1]

511.4.1 Connections. The bleed air ducts shall connect to the top or side of the master exhaust duct. [NFPA 96:8.4.2]

511.4.2 Fire Damper. The bleed-air duct shall have a fire damper not less than 12 inches (305 mm) from the exhaust duct connection. [NFPA 96:8.4.3]

511.4.3 Construction and Clearance. The bleed-air duct shall have the same construction and clearance requirements as the main exhaust duct from the connection to the exhaust duct to not less than 12 inches (305 mm) on both sides of the fire damper. [NFPA 96:8.4.4]

511.4.4 Adjustment. Each bleed air duct shall have a means of adjusting (e.g., by using volume dampers) the bleed air quantity. [NFPA 96:8.4.5]

511.4.5 Adjustment Location. Means to adjust the bleed air quantity shall be installed between the fire damper and the source of bleed air. [NFPA 96:8.4.6]

511.4.6 Bleed Air Duct. A bleed air duct shall not be used for the exhaust of grease-laden vapors and shall be so labeled. [NFPA 96:8.4.7]

511.4.7 Disconnect. Unused tenant exhaust connections to the master exhaust duct that are not used as bleed air connections shall be disconnected and sealed at the main duct. [NFPA 96:8.4.8]
511.5 **Solid-Fuel Air Movement Requirements.** Where solid-fuel cooking equipment is used, exhaust and replacement air also shall be in accordance with Section 517.0.

512.0 **Auxiliary Equipment.**

512.1 **Dampers.** Dampers shall not be installed in exhaust ducts or exhaust duct systems. [NFPA 96:9.1.1]

512.1.1 **Use.** Where specifically listed for such use or where required as part of a listed device or system, dampers in exhaust ducts or exhaust duct systems shall be permitted. [NFPA 96:9.1.2]

512.2 **Electrical Equipment.** Wiring systems of any type shall not be installed in ducts. [NFPA 96:9.2.1]

512.2.1 **Device Installation in Ducts.** Motors, lights, and other electrical devices shall be permitted to be installed in ducts or hoods or to be located in the path of travel of exhaust products only where specifically listed for such use. [NFPA 96:9.2.2]

512.2.2 **Lighting Units.** Lighting units in hoods shall not be located in concealed spaces except as permitted by Section 512.2.3 and Section 512.2.4. [NFPA 96:9.2.3.2]

512.2.3 **Concealed Spaces.** Lighting units shall be permitted in concealed spaces where such units are part of a listed exhaust hood. [NFPA 96:9.2.3.3]

512.2.4 **Listed Lighting Units.** Listed lighting units specifically listed for such use and installed in accordance with the terms of the listing shall be permitted to be installed in concealed spaces. [NFPA 96:9.2.3.4]

512.2.5 **Standard.** Electrical equipment shall be installed in accordance with NFPA 70, with due regard to the effects of heat, vapor, and grease on the equipment.

512.3 **Other Equipment.** Fume incinerators, thermal recovery units, air pollution control devices, or other devices shall be permitted to be installed in ducts, or hoods or to be located in the path of travel of exhaust products where specifically listed for such use. [NFPA 96:9.3.1]

512.3.1 **Access Required.** Equipment shall have space provided to all access panels or doors for the safe removal and servicing of control devices, such as filters, electrostatic precipitator cells, and odor control media beds, and for cleaning of the equipment housing. [NFPA 96:9.3.1.3]

512.3.2 **Downgrading.** Downgrading other parts of the exhaust system due to the installation of these approved devices, whether listed or not, shall not be permitted allowed. [NFPA 96:9.3.1.9.3.2]

512.3.3.1 **Fire-Extinguishing System.** Any equipment, listed or otherwise, installed in the path of exhaust products that provides secondary filtration or air pollution control and that is installed in the path of travel of exhaust products shall be provided with an approved automatic fire-extinguishing system, installed in accordance with the fire-extinguishing system manufacturer’s installation instructions. [NFPA 96:9.3.3.3]

512.3.3.1 **Protection.** The fire-extinguishing system required by Section 512.3.3 shall provide protection for the component sections of the equipment, and shall include protection of the ductwork downstream of the equipment, whether or not the equipment is provided with a damper. [NFPA 96:9.3.3.4]

512.3.3.2 **Filter Media.** Filter media used in secondary filtration or air pollution control units and not in accordance complying with Section 509.2.3 shall have fire protection that is adequate for the filter media being used in accordance with the fire-extinguishing system manufacturer’s installation instructions. [NFPA 96:9.3.3.2]

512.3.3.4 **Source of Ignition.** Where if the equipment provides a source of ignition, it shall be provided with a detection to operate the fire-extinguishing system protecting the equipment. [NFPA 96:9.3.3.4]

512.3.5 **Air Recirculation.** Where a cooking exhaust system employs an air pollution control device that recirculates air into the building, the requirements of Section 516.0 shall apply. [NFPA 96:9.3.5]

512.4 **Solid-Fuel Auxiliary Equipment.** Where solid fuel cooking comprises a part of a cooking operation, additional provisions, and equipment as described in Section 517.0 shall be used where required.

513.0 **Fire-Extinguishing Equipment.**

513.1 **General.** Fire-extinguishing equipment for the protection of grease removal devices, hood exhaust plenums, and exhaust duct systems shall be provided. [NFPA 96:10.1.1]

513.1.1 **Devices in Exhaust Ducts.** Fume incinerators, thermal recovery units, air pollution control devices, or other devices installed in the exhaust duct, shall be protected by an automatic fire-extinguishing system. [NFPA 96:10.1.3]

513.1.2 **Protection.** Cooking equipment that produces grease-laden vapors and is capable of being a source of ignition of grease in the hood, grease removal device, or duct shall be protected by fire-extinguishing equipment. [NFPA 96:10.1.2]

513.2 **Types of Equipment.** Fire-extinguishing equipment shall include both automatic fire-extinguishing systems as primary protection and portable fire extinguishers as secondary backup. [NFPA 96:10.2.1]

513.2.1 **Identification.** A placard shall be conspicuously placed near the fire each Class K extinguisher that states that the fire protection system shall be activated prior to using the fire extinguisher. [NFPA 96:10.2.2]

513.2.2 **Standard.** Automatic fire-extinguishing systems shall comply with UL 300 or other equivalent standards and shall be installed in accordance with the requirements of the listing. In existing dry or wet chemical systems not in accordance with UL 300, the fire-extinguishing system shall be made in accordance with this section where one of the following occurs:
(1) The cooking medium is changed from animal oil and fat to vegetable oil.
(2) The positioning of the cooking equipment is changed.
(3) Cooking equipment is replaced.
(4) The equipment is no longer supported by the manufacturer. [NFPA 96:10.2.3, 10.2.3.1]

Exception: Automatic fire-extinguishing equipment provided as part of listed recirculating systems in accordance with UL 710B. [NFPA 96:10.2.5]

513.2.3 Installation. Automatic fire-extinguishing systems shall be installed in accordance with the terms of their listing, the manufacturer’s installation instructions, and the following standards where applicable:
(1) NFPA 12
(2) NFPA 13
(3) NFPA 17
(4) NFPA 17A

513.2.4 Modification of Existing Hood Systems. An abandoned pipe or conduit from a previous installation shall be removed from within the hood, plenum, and exhaust duct. [NFPA 96:10.2.7.1]

513.2.4.1 Sealing. Penetrations and holes resulting from the removal of conduit or piping shall be sealed with listed or equivalent liquid-tight sealing devices. [NFPA 96:10.2.7.2]

513.2.4.2 Obstructions. The addition of obstructions to spray patterns from the cooking appliance nozzle(s) such as baffle plates, shelves, or a modification shall not be permitted. [NFPA 96:10.2.7.3]

513.2.4.3 System Re-evaluation. Changes or modifications to the hazard after installation of the fire-extinguishing systems shall result in re-evaluation of the system design by a properly trained, qualified, and certified person(s). [NFPA 96:10.2.7.4]

513.2.5 Fixed-Baffle Hoods with Water Wash. Grease removal devices, hood exhaust plenums, and exhaust ducts shall be permitted to be protected by a fixed baffle hood containing a constant or fire-actuated water-wash system that is listed as a fire-extinguishing system in accordance with UL 300 or other equivalent standards and shall be installed in accordance with the requirements of its listing. [NFPA 96:10.2.8.1]

513.2.5.1 Listed for the Purpose. Each such area not provided with a listed water-wash fire-extinguishing system shall be provided with a fire-extinguishing system listed for the purpose. [NFPA 96:10.2.8.2]

513.2.5.2 Domestic Water Supply. The water supply for listed, fixed baffle hood assemblies water-wash fire-extinguishing systems shall be permitted to be supplied from the domestic water supply. [NFPA 96:10.2.8.3]

513.2.5.3 Control Valve. The water supply for water-wash fire-extinguishing systems shall be controlled by a supervised water supply control listed indicating valve. [NFPA 96:10.2.8.4]

513.2.5.4 Activation. The water wash system shall be activated by the cooking equipment fire-extinguishing system. Where a separate fire-extinguishing system is used for protection of cooking equipment only, a water-wash fire-extinguishing system listed for protection of the grease removal device(s), hood exhaust plenum(s), exhaust duct(s), or combination thereof shall be provided with instructions and appropriate means for electrical interface for simultaneous activation. [NFPA 96:10.2.8.5]

513.2.5.5 Water-Wash System. A water-wash system approved to be used for protection of the grease removal device(s), hood exhaust plenum(s), exhaust duct(s), or combination thereof shall include instructions and appropriate means for electrical interface for simultaneous activation of the water-wash system from an automatic fire-extinguishing system, where the automatic fire-extinguishing system is used for cooking equipment protection only. [NFPA 96:10.2.8.6]

513.2.5.6 Exception. Where the automatic fire-extinguishing system in accordance with NFPA 17A provides protection for the cooking equipment, hood, and duct, activation of a fixed baffle hood containing a water-wash system, the water-wash system shall not be required to be inoperable or delayed for a minimum of 60 seconds upon operation of the automatic fire-extinguishing system. [NFPA 96:10.2.8.7]

513.2.5.7 Water Supply. The water supply required for listed automatic fire-extinguishing systems shall be permitted to be supplied from the domestic water supply where the minimum water pressure and flow are provided in accordance with the terms of the listing. The water supply shall be controlled by a supervised water supply control valve. Where the water supply is from a dedicated fire protection water supply in a building with one or more fire sprinkler systems, separate indicating control valves and drains shall be provided and arranged so that the hood system and sprinkler system are capable of being systems can be controlled individually. [NFPA 96:10.2.9.1, 10.2.9.2]

513.2.6 Water Valve Supervision. Valves controlling the water supply to listed fixed baffle hood assemblies water-wash fire-extinguishing systems, automatic fire-extinguishing systems, or both shall be listed indicating type of valve and shall be supervised open by one of the following methods:
(1) Central station, proprietary, or remote station alarm service.
(2) Local alarm service that will cause the sounding of an audible signal at a constantly attended point.
EXHAUST SYSTEMS

513.3 Simultaneous Operation. Fixed pipe extinguishing systems in a single hazard area shall be arranged for simultaneous automatic operation upon actuation of any one of the systems. [NFPA 96:10.3.1]

513.3.1 Hoods. Hoods installed end to end, back to back, or both, or sharing a common ductwork, not exceeding 75 feet (22,860 mm) in distance from the farthest hood, and having a grease producing appliance(s) located under one or more of the hoods, shall be considered a single hazard area requiring simultaneous automatic fire protection in all hoods and ducts. [NFPA 96:10.3.1.1]

513.3.2 Independent Systems. Hoods installed end to end, back to back, or both that do not share a common exhaust duct and are separated by a wall(s) or other means to ensure that grease-laden vapors exhausted under one hood cannot propagate to the other hoods, the hoods’ fire-extinguishing system(s) shall be independent and shall not be required to simultaneously discharge. [NFPA 96:10.3.1.2]

513.3.3 Exempt Equipment. Fume incinerators, thermal recovery units, air pollution control devices, or other devices installed in the exhaust duct shall not be required to comply with Section 513.3.1. [NFPA 96:10.3.1.3]

513.4 Fuel and Electric Power Shutoff. Upon activation of a fire-extinguishing system for a cooking operation, sources of fuel and electric power that produce heat to equipment requiring protection by that system shall automatically shut off. [NFPA 96:10.4.1]

513.4.2 Protection Not Required. A gas appliance not requiring protection, but located under ventilating equipment where protected appliances are located, shall be automatically shut off upon activation of the extinguishing system. [NFPA 96:10.4.3]

513.4.3 Manual Reset. Shutoff devices shall require manual reset. [NFPA 96:10.4.4]

513.5 Manual Activation. A readily accessible means for manual activation shall be located between 42 inches and 48 inches (1067 mm and 1219 mm) above the floor, and be accessible in the event of a fire, be located in a path of egress, and clearly identify the hazard protected. Not less than one manual actuation device shall be located not less than 10 feet (3048 mm) and not more than 20 feet (6096 mm) from the protected exhaust system(s) within the path of egress or at an alternative location acceptable to the Authority Having Jurisdiction. Manual actuation using a cable-operated pull station shall not require more than 40 pounds force (180 N) of force, with a pull movement not to exceed 11 inches (256 mm) to activate the automatic fire extinguishing system. The automatic and manual means of system activation external to the control head or releasing device shall be separate and independent of each other so that failure of one will not impair the operation of the other except as permitted in Section 513.5.1. All systems shall have both automatic and manual methods of actuation. At least one manual actuation device shall be located in a means of egress or at a location acceptable to the Authority Having Jurisdiction.

The manual actuation device shall clearly identify the hazard protected. An automatic sprinkler system shall not require a method of manual activation. [NFPA 96:10.5.1 – 10.5.2]

513.5.1 Location of Manual Activation Device. The means of system activation shall be permitted to be common with the automatic means where the manual activation device is serving the occupancy where the extinguishing system is located between the control head or releasing device and the first fusible link. [NFPA 96:10.5.2]

513.5.2 Automatic Sprinkler System. An automatic sprinkler system shall not require a manual means of system activation. [NFPA 96:10.5.4]

513.5.3 Manual Actuator(s). The means for manual activation shall be mechanical or rely on electrical power for activation in accordance with Section 513.5.4. [NFPA 96:10.5.5]

513.5.4 Standby Power Supply. Electrical power shall be permitted to be used for manual activation where a standby power supply is provided or where supervision is provided in accordance with Section 513.7. [NFPA 96:10.5.6]

513.6 System Annunciation. Upon activation of an automatic fire-extinguishing system, an audible alarm or visual indicator shall be provided to show that the system has activated. [NFPA 96:10.6.1]

513.6.1 Signaling. Where a fire alarm signaling system is serving the occupancy where the extinguishing system is located, the activation of the automatic fire-extinguishing system shall activate the fire alarm signaling system. [NFPA 96:10.6.2]

513.7 System Supervision. Where electrical power is required to operate the fixed automatic fire-extinguishing sys-
513.7.1 Automatic Fire-Extinguishing System. Where a fixed automatic fire-extinguishing system includes automatic mechanical detection and actuation as a backup detection system, electrical power monitoring, and reserve power supply shall not be required. [NFPA 96:10.7.1]

513.7.2 Supervision. System supervision shall not be required where a fire-extinguishing system(s) is interconnected or interlocked with the cooking equipment power source(s) so that where the fire-extinguishing system becomes inoperable due to power failure, sources of fuel or electric power that produce heat to cooking equipment serviced by that hood shall automatically shut off. [NFPA 96:10.7.2]

513.7.3 Listed Water Wash System. System supervision shall not be required where an automatic fire-extinguishing system, including automatic mechanical detection and actuation, is electrically connected to a listed fire-actuated water wash system for simultaneous operation of both systems. [NFPA 96:10.7.3]

513.8 Special Design and Application. Hoods containing automatic fire-extinguishing systems are protected areas; therefore, these hoods shall not be considered obstructions to overhead sprinkler systems and shall not require floor additional sprinkler coverage underneath. [NFPA 96:10.8.1]

513.8.1 Single Device. A single detection device listed with the extinguishing system shall be permitted for more than one appliance where installed in accordance with the terms of the listing. [NFPA 96:10.8.2]

513.8.2 Multiple Devices. Multiple detection devices listed with the extinguishing system shall be permitted for more than one appliance where installed in accordance with the terms of the listing. [NFPA 96:10.8.3]

513.8.3 Automatic Mechanical Systems. Automatic mechanical systems shall be permitted in accordance with the instruction or the equipment listing. [NFPA 96:10.8.4]

513.8.4 Piping, Nozzles, and Sprinklers. Piping, nozzles, and sprinklers shall be permitted in accordance with the instruction or the equipment listing. [NFPA 96:10.8.5]

513.8.5 Reserve Power Supply. Reserve power supply shall not be required. [NFPA 96:10.8.6]

513.8.6 System Supervision. System supervision shall not be required where an automatic fire-extinguishing system, including automatic mechanical detection and actuation, is electrically connected to a listed fire-actuated water wash system for simultaneous operation of both systems. [NFPA 96:10.8.7]

513.9 Review and Certification. Where required, complete drawings of the system installation, including the hood(s), exhaust duct(s), and appliances, along with the interface of the fire-extinguishing system detectors, piping, nozzles, fuel and electric power shutoff devices, agent storage container(s), and manual actuation device(s), shall be submitted to the Authority Having Jurisdiction. [NFPA 96:10.9.1]

513.10 Installation Requirements. Installation of systems shall be performed only by persons properly trained and qualified to install the specific system being provided. The installer shall provide certification to the Authority Having Jurisdiction that the installation is in agreement with the terms of the listing and the manufacturer’s instructions. [NFPA 96:10.10.2]

513.11 Maintenance. Portable fire extinguishers shall be maintained in accordance with NFPA 10. [NFPA 96:10.10.4

514.1 Operating Procedures. Exhaust systems shall be operated whenever cooking equipment is turned on. [NFPA 96:11.1.1]

514.1.1 Filters. Filter-equipped exhaust systems shall not be operated with filters removed. [NFPA 96:11.1.2]

514.1.2 Openings. Openings provided for replacing air exhausted through ventilating equipment shall not be restricted by covers, dampers, or other means that would reduce the operating efficiency of the exhaust system. [NFPA 96:11.1.3]

514.1.3 Posting of Instructions. Instructions for manually operating the fire-extinguishing system shall be posted conspicuously in the kitchen and shall be reviewed with employees by the management. [NFPA 96:11.1.4]

514.1.4 Listing and Manufacturer’s Instructions. Listed exhaust hoods shall be operated in accordance with the terms of their listings and the manufacturer’s instructions. [NFPA 96:11.1.5]

514.1.5 Nonoperational. Cooking equipment shall not be operated while its fire-extinguishing system or exhaust system is nonoperational or impaired. [NFPA 96:11.1.6]

514.1.6 Secondary Control Equipment. Secondary filtration and pollution control equipment shall be operated in accordance with the terms of its listing and the manufacturer’s instructions. [NFPA 96:11.1.7]

514.1.7 Inspection Frequency. Inspection and maintenance of “other equipment” as allowed in Section 512.3 shall be conducted by properly trained and qualified persons at a frequency determined by the manufacturer’s instructions or the equipment listing. [NFPA 96:11.1.8]

514.2 Inspection, Testing, and Maintenance. Maintenance of the fire-extinguishing systems and listed exhaust hoods containing a constant or fire-activated water system that is listed to extinguish a fire in the grease removal devices, hood exhaust plenums, and exhaust ducts shall be made by properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction not less than at least every 6 months. [NFPA 96:11.2.1]

514.2.1 Requirements. Actuation of fire extinguishing systems, including remote manual pull stations, mechanical and electrical devices, detectors, and actuators, shall be tested for proper operation during the inspection
514.4 Cleaning of Exhaust Systems. Where, upon inspection, the exhaust system is found to be contaminated with deposits from grease-laden vapors, the contaminated portions of the exhaust system shall be cleaned by a properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.6.1]

514.4.1 Measurement System. A measurement system of deposition shall be established to trigger a need to clean when the exhaust system is inspected at the frequencies in Table 514.3. [NFPA 96:11.6.1.1]

514.4.1.1 Combustible Contaminants. Hoods, grease removal devices, fans, ducts, and other appurtenances shall be cleaned to remove combustible contaminants to a minimum of 0.002 of an inch (50 µm). [NFPA 96:11.6.1.1.1]

514.4.1.2 Gauge Comb. A grease depth gauge comb as shown in Figure 514.4.1.2 shall be placed upon the surface to measure grease depth. [NFPA 96:11.6.1.1.2]

514.4.1.3 Cleaning Method. Where a measured depth of 0.078 of an inch (2000 µm) is observed, the surfaces shall be cleaned in accordance with Section 514.4. [NFPA 96:11.6.1.1.3]

514.4.1.4 Combustible Contaminants. Where a measured depth of 0.125 of an inch (3175 µm) is observed, the surfaces shall be cleaned in accordance with Section 514.4. [NFPA 96:11.6.1.1.4]

514.4.2 Removal of Contaminants. Hoods, grease removal devices, fans, ducts, and other appurtenances shall be cleaned to remove combustible contaminants prior to surfaces becoming heavily contaminated with grease or oily sludge. [NFPA 96:11.6.2]

514.4.2.1 Electrical Switches. At the start of the cleaning process, electrical switches that could be activated accidentally shall be locked out. [NFPA 96:11.6.3]

514.4.2.2 Fire Suppression System. Components of the fire suppression system shall not be rendered inoperable during the cleaning process. [NFPA 96:11.6.4]

514.4.2.3 Inoperable. Fire-extinguishing systems shall be permitted to be rendered inoperable during the cleaning process where serviced by properly trained and qualified persons. [NFPA 96:11.6.5]
514.4.5 Solvents/Cleaning Aids. Flammable solvents or other flammable cleaning aids shall not be used. [NFPA 96:11.6.6]

514.4.6 Cleaning Chemicals. Cleaning chemicals shall not be applied on fusible links or other detection devices of the automatic extinguishing system. [NFPA 96:11.6.7]

514.4.7 Coating. After the exhaust system is cleaned, it shall not be coated with powder or other substance. [NFPA 96:11.6.8]

514.4.8 Access Panels and Cover Plates. When cleaning procedures are completed, all access panels (doors) and cover plates shall be restored to their normal operational condition. [NFPA 96:11.6.9]

514.4.9 Date of Inspection. When an access panel is removed, a service company label or tag preprinted with the name of the company and giving the date of inspection or cleaning shall be affixed near the affected access panel. [NFPA 96:11.6.10]

514.4.10 Airflow. Dampers and diffusers shall be positioned for proper airflow. [NFPA 96:11.6.11]

514.4.11 Operable State. When cleaning procedures are completed, all electrical switches and system components shall be returned to an operable state. [NFPA 96:11.6.12]

514.4.12 Certification of Service. When an exhaust cleaning service system is inspected or cleaned, a certificate showing the name of the servicing company, the name of the person performing the work, and the date of inspection or cleaning shall be maintained on the premises. [NFPA 96:11.6.13]

514.4.13 Report Provided. After cleaning or inspection is completed, the exhaust cleaning company and the person performing the work at the location shall provide the owner of the system with a written report that also specifies areas that were inaccessible or not cleaned. [NFPA 96:11.6.14]

514.4.14 Unclean Area. Where required, certificates of inspection and cleaning and reports of areas not cleaned shall be submitted to the Authority Having Jurisdiction. [NFPA 96:11.6.15]

514.4.15 Metal Containers. Metal containers used to collect grease drippings shall be inspected or emptied at least weekly. [NFPA 96:11.6.16]

514.5 Cooking Equipment Maintenance. Inspection and servicing of the cooking equipment shall be made not less than at least annually by properly trained and qualified persons. [NFPA 96:11.7.1]

514.5.1 Cleaning. Cooking equipment that collects grease below the surface, behind the equipment, or in cooking equipment flue gas exhaust, such as griddles or charbroilers, shall be inspected and, where found with grease accumulation, cleaned by a properly trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.7.2]

515.0 Minimum Safety Requirements for Cooking Equipment.

515.1 Cooking Equipment. Cooking equipment shall be approved based on one of the following criteria:

1. Listings by a testing laboratory.

2. Test data acceptable to the Authority Having Jurisdiction. [NFPA 96:12.1.1]

515.1.1 Installation. All listed appliances shall be installed in accordance with the terms of their listings and the manufacturer’s installation instructions. Solid fuel used for flavoring within a gas-operated appliance shall be in a solid fuel holder (smoker box) that is listed with the equipment. [NFPA 96:12.1.2.1, 12.1.2.1.1]

515.1.2 Re-evaluation. Cooking appliances requiring protection shall not be moved, modified, or rearranged without prior re-evaluation of the fire-extinguishing system by the system installer or servicing agent, unless otherwise allowed by the design of the fire-extinguishing system. A solid fuel holder shall not be added to an existing appliance until the fire-extinguishing system has been evaluated by the fire-extinguishing system service provider. [NFPA 96:12.1.2.2, 12.1.2.2.1]

515.1.3 Minimum Space. Deep-fat fryers shall be installed with not less than a 16 inch (406 mm) space between the fryer and surface flames from adjacent cooking equipment. [NFPA 96:12.1.2.3]

515.1.4 Space Not Required. Where a steel or tempered glass baffle plate is installed not less than 8 inches (203 mm) in height between the fryer and surface flames from adjacent appliance, the requirement for a 16 inch (406 mm) space shall not apply. [NFPA 96:12.1.2.5]

515.1.5 Minimum Height. Where the fryer and the surface flames are at different horizontal planes, a height of not less than 8 inches (203 mm) shall be measured from the higher of the two. [NFPA 96:12.1.2.5.1]

515.2 Operating Controls. Deep-fat fryers shall be equipped with a separate high-limit control in addition to the adjustable operating control (thermostat) to shut off fuel or energy when the fat temperature reaches 475°F (246°C) at 1 inch (25.4 mm) below the surface. [NFPA 96:12.2]
516.0 Recirculating Systems.

516.1 General Requirements. Recirculating systems containing or for use with appliances used in processes producing smoke or grease-laden vapors shall be equipped with components in accordance with the following:

1. The clearance requirements of Section 507.4.
2. The hood shall comply with the requirements of Section 508.0.
3. Grease removal devices shall comply with Section 509.0.
4. The air movement requirements of Section 511.2.1 and Section 511.2.2.
5. Auxiliary equipment (such as particulate and odor removal devices) shall comply with Section 512.0.
6. Fire-extinguishing equipment shall comply with the requirements of Section 513.0.

Exception: Fire-extinguishing equipment in accordance with Section 513.1 and Section 513.5.

7. The use and maintenance requirements of Section 514.0.
8. The minimum safety requirements of Section 515.0.
9. The requirements of Section 516.0. [NFPA 96:13.1]
10. Provisions shall be provided for latent heat and excessive moisture acceptable to the Authority Having Jurisdiction.

516.2 Design Restrictions. Recirculating systems shall comply with Section 516.2.1 through Section 516.2.9. [NFPA 96:13.2]

516.2.1 Gas/Electrically Fueled Cooking Appliances. Gas-fueled or electrically fueled cooking appliances shall be used. Listed gas-fueled equipment designed for use with specific recirculating systems shall have the flue outlets connected in the intended manner. Gas-fueled appliances shall have not less than 18 inches (457 mm) of clearance from the flue outlet to the filter inlet in accordance with Section 509.2.2 through Section 509.2.2.3 and shall be in accordance with the installation requirements of NFPA 54 or NFPA 58. [NFPA 96:13.2.1 – 13.2.3]

516.2.2 Recirculation. Recirculating systems shall be listed with a testing laboratory in accordance with UL 710B or equivalent. [NFPA 96:13.2.4]

516.2.3 Protection. Cooking appliances that require protection and that are under a recirculating hood shall be protected by either the integral fire protection system in accordance with UL 710B or Section 513.0. [NFPA 96:13.2.4.2]

516.2.4 Maximum Limits. A recirculating system shall not use cooking equipment that exceeds that recirculating system’s labeled maximum limits for that type of equipment, stated in maximum energy input, maximum cooking temperature, and maximum square area of cooking surface or cubic volume of cooking cavity. [NFPA 96:13.2.6]

516.2.5 Label. The listing label shall show the type(s) of cooking equipment tested and the maximum limits specified in Section 516.2.4. [NFPA 96:13.2.7]

516.2.6 Fire Damper. A fire-actuated damper shall be installed at the exhaust outlet of the system. [NFPA 96:13.2.8] The actuation device for the fire damper shall have a maximum temperature rating of 375°F (191°C). [NFPA 96:13.2.10]

516.2.7 Installation of Electrical Wiring. No electrical wiring shall be installed in the interior sections of the hood plenum that is capable of becoming exposed to grease. Exception: As permitted by NFPA 70.

516.2.8 Power Supply. The power supply of an electrostatic precipitator (ESP) shall be of the “cold spark,” ferroresonant type in which the voltage falls off as the current draw of a short increases. [NFPA 96:13.2.11]

516.2.9 Listing Evaluation. Listing evaluation shall include the following:

1. Capture and containment of vapors at published and labeled airflows.
2. Grease discharge at the exhaust outlet of the system not to exceed an average of 2.9 E-09 (oz/in3) (5.0 E-06 kg/m3) of exhausted air sampled from that equipment at maximum amount of product that is capable of being processed over a continuous 8 hour test with the system operating at its minimum listed airflow.
3. Listing and labeling of clearance to combustibles from the all sides, top, and bottom.
4. Electrical connection in the field in accordance with NFPA 70.
5. Interlocks on all removable components that lie in the path of airflow within the unit to ensure that they are in place during operation of the cooking appliance. [NFPA 96:13.2.12]

516.3 Interlocks. The recirculating system shall be provided with interlocks of critical components and operations as indicated in Section 516.3.1 through Section 516.3.3.1 such that, where an interlock is interrupted, the cooking appliance shall not be able to operate. [NFPA 96:13.3.1]

516.3.1 Airflow Sections. Closure panels encompassing airflow sections shall have interlocks to ensure that the panels are in place and fully sealed. [NFPA 96:13.3.2]

516.3.2 Filter Component. Each filter component (grease and odor) shall have an interlock to prove the component is in place. [NFPA 96:13.3.3]

516.3.3 ESP Interlocks. Each ESP shall have a sensor to prove its performance is as designed, with no interruption of the power to exceed 2 minutes. [NFPA 96:13.3.4.1]

516.3.3.1 Manual Reset. The sensor shall be a manual reset device or circuit. [NFPA 96:13.3.4.2]

516.3.4 Airflow Switch or Transducer. An airflow switch or transducer shall be provided after the last filter component to ensure that a minimum airflow is maintained. The airflow switch or transducer shall open the interlock circuit when the airflow falls 25 percent below the system’s normal operating flow or 10 percent below its listed minimum rating, whichever is lower. The
airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:13.3.5.1 – 13.3.5.3]

516.4 Location and Application Restrictions. The location of recirculating systems shall be approved by the Authority Having Jurisdiction. Items to be reviewed in the fire risk assessment shall include, but not be limited to, life safety, combustibility of surroundings, proximity to air vents, and total fuel load. [NFPA 96:13.4]

516.5 Additional Fire Safety Requirements. In addition to the appliance nozzle(s), a recirculating system shall be listed with the appropriate fire protection for grease filters, grease filtration, odor filtration units, and ductwork, where applicable. [NFPA 96:13.5.1]

516.5.1 Installation Downstream. In addition to other fire-extinguishing system activation device, there shall be a fire-extinguishing system activation device installed downstream of an ESP. [NFPA 96:13.5.2]

516.5.2 Locations. The requirements of Section 513.6 shall also apply to recirculating system locations. [NFPA 96:13.5.3]

516.6 Use and Maintenance. Automatic or manual covers on cooking appliances, especially fryers, shall not interfere with the application of the fire suppression system. [NFPA 96:13.6.1]

516.6.1 Manufacturer’s Instructions. Filters shall be cleaned or replaced in accordance with the manufacturer’s instructions. [NFPA 96:13.6.2]

516.6.2 Cleaning Schedule. All ESPs shall be cleaned a minimum of once per week and in accordance with the manufacturer’s cleaning instructions. [NFPA 96:13.6.3]

516.6.3 Hood Plenum and Blower Section Cleaning Schedule. The entire hood plenum and the blower section shall be cleaned no less than a minimum of once every 3 months. [NFPA 96:13.6.4]

516.6.4 Inspection of Safety Interlocks. Inspection and testing of the total operation and all safety interlocks in accordance with the manufacturer’s instructions shall be performed by qualified service personnel not less than a minimum of once every 6 months, or more frequently if required. [NFPA 96:13.6.5]

516.6.5 Inspection. Fire-extinguishing equipment shall be inspected in accordance with Section 514.2. [NFPA 96:13.6.6]

516.6.6 Maintenance Log. A signed and dated log of maintenance as performed in accordance with Section 516.6.3 and Section 516.6.4 shall be available on the premises for use by the Authority Having Jurisdiction. [NFPA 96:13.6.7]

517.0 Solid-Fuel Cooking Operations.

517.1 Venting Application. Venting requirements of solid-fuel cooking operations shall be determined in accordance with Section 517.1.1 through Section 517.1.6. [NFPA 96:14.1]

517.1.1 Natural Draft. Where solid-fuel cooking equipment is required by the manufacturer to have a natural draft, the vent shall be in accordance with Section 517.4. [NFPA 96:14.1.1]

517.1.2 System Compliance. Where the solid-fuel cooking equipment has a self-contained top, the appliance to be vented in an isolated space (except for a single water heater with its own separate vent), has a separate makeup air system, and is provided with supply and return air (not supplied or returned from other spaces), the system shall be in accordance with Section 517.4 and Section 517.6. [NFPA 96:14.1.2]

517.1.3 Makeup Air System. Where the solid-fuel cooking equipment is located in a space with other vented equipment, the vented equipment shall have an exhaust system interlocked with a makeup air system for the space in accordance with Section 517.6. [NFPA 96:14.1.3]

517.1.4 Natural Draft Ventilation Systems. Natural draft ventilation systems and power-exhausted ventilation systems shall comply with Section 517.3, Section 517.4, and Section 517.6. [NFPA 96:14.1.4]

517.1.5 Opening Requirements. Where a solid-fuel cooking appliance allows effluent to escape from the appliance opening, this opening shall be covered by a hood and an exhaust system that meets the requirements of Section 517.3, Section 517.4, and Section 517.6. [NFPA 96:14.1.5]

517.1.6 Spark Arresters. Solid-fuel cooking operations shall have spark arresters to minimize the passage of airborne sparks and embers into plenums and ducts. Where the solid-fuel cooking operation is not located under a hood, a spark arrester shall be provided to minimize the passage of sparks and embers into flues and chimneys. [NFPA 96:14.1.6, 14.1.7]

5172 Location of Appliances. Appliances shall be located with respect to building construction and other equipment so as to permit access to the appliance. [NFPA 96:14.2.1]

5172.1 Prohibited Location. Solid-fuel cooking appliances shall not be installed in confined spaces. [NFPA 96:14.2.2]

Exception: Solid-fuel cooking appliances listed for installation in confined spaces such as alcoves shall be installed in accordance with the terms of the listing and the manufacturer’s installation instructions. [NFPA 96:14.2.3]

5172.2 Flammable Vapors. Solid-fuel cooking appliances shall not be installed in a location where gasoline or other flammable vapors or gases are present. [NFPA 96:14.2.4]

5173 Hoods for Solid-Fuel Cooking. Hoods shall be sized and located in a manner capable of capturing and containing the effluent discharging from the appliances. The hood and its exhaust system shall be in accordance with the provisions of Section 508.0 through Section 513.0. [NFPA 96:14.3.1, 14.3.2]

5173.1 Separation. Except as permitted in Section 517.3.1.1, exhaust systems serving solid-fuel cooking equipment, including gas or electrically operated equipment, shall be separate from other exhaust systems. [NFPA 96:14.3.3]
EXHAUST SYSTEMS

**5173.1.1 Equipment with Solid Fuel for Flavoring.** Gas-operated equipment utilizing solid fuel for flavoring that is in accordance with Section 517.1 shall be provided.

Exception: Cooking equipment not requiring automatic fire-extinguishing equipment (in accordance with Section 513.0) shall be permitted to be installed under a common hood with solid-fuel cooking equipment that is served by a duct system separate from other exhaust systems. [NFPA 96:14.3.5]

5174 Exhaust Systems for Solid-Fuel Cooking. Where a hood is not required, in buildings where the duct system does not exceed is three stories or less in height, a duct complying with Section 510.0 shall be provided. [NFPA 96:14.4]

**5174.1 Hood.** Where a hood is used in buildings where the duct system does not exceed is three stories in height, the duct system shall be in accordance comply with Section 510.0. [NFPA 96:14.4.1]

**5174.2 Building Exceeding Four Stories.** A listed or approved grease duct system that is four stories in height or more greater shall be provided for solid-fuel cooking exhaust systems. [NFPA 96:14.4.2]

**5174.3 Prohibited.** Wall terminations of solid-fuel exhaust systems shall be prohibited. [NFPA 96:14.4.4]

**5175 Grease Removal Devices for Solid-Fuel Cooking.** Grease removal devices shall be constructed of steel or stainless steel or be approved for solid-fuel cooking. [NFPA 96:14.5.1]

**5175.1 Spark Arrester Devices.** Where airborne sparks and embers can be generated by the solid-fuel cooking operation, spark arrester devices shall be used prior to using the grease removal device, to minimize the entrance of these sparks and embers into the grease removal device and into the hood and the duct system. [NFPA 96:14.5.2]

**5175.2 Filters.** Filters shall be not less than 4 feet (1219 mm) above the appliance cooking surface. [NFPA 96:14.5.3]

**5176 Air Movement for Solid-Fuel Cooking.** Exhaust system requirements shall comply with Section 511.0 for hooded operation or shall be installed in accordance with the manufacturer’s installation instructions recommendations for unhooded applications. [NFPA 96:14.6.1]

**5176.1 Replacement Air.** A replacement or makeup air system shall be provided to ensure a positive supply of replacement air at times during cooking operations. [NFPA 96:14.6.2]

**5176.2 Operation.** Makeup air systems serving solid-fuel cooking operations shall be interlocked with the exhaust air system and powered, where necessary, to prevent the space from attaining a negative pressure while the solid-fuel appliance is in operation. [NFPA 96:14.6.3]

**5177 Fire-Extinguishing Equipment for Solid-Fuel Cooking.** Solid-fuel cooking appliances that produce grease-laden vapors shall be protected by listed fire-extinguishing equipment.

**Exception:** Where acceptable to the Authority Having Jurisdiction, solid-fuel cooking appliances constructed of solid masonry or reinforced portland or refractory cement concrete and vented in accordance with NFPA 211 shall not require fixed automatic fire-extinguishing equipment. [NFPA 96:14.7.1, 14.7.2]

**5177.1 Grease Removal Devices, Hoods, and Duct Systems.** Listed fire-extinguishing equipment shall be provided for the protection of grease removal devices, hoods, and duct systems. [NFPA 96:14.7.3]

**Exception:** Where acceptable to the Authority Having Jurisdiction, solid-fuel cooking appliances constructed of solid masonry or reinforced portland or refractory cement concrete and vented in accordance with NFPA 211 shall not require automatic fire-extinguishing equipment for the protection of grease removal devices, hoods, and duct systems. [NFPA 96:14.7.4]
517.7.2 Listed Fire-Extinguishing Equipment. Listed fire-extinguishing equipment for solid-fuel-burning cooking appliances, where required, shall be in accordance with Section 513.0 and shall use water-based agents. [NFPA 96:14.7.5]

517.7.3 Rating and Design. The fire-extinguishing equipment shall be rated and designed to extinguish solid-fuel cooking fires. The fire-extinguishing equipment shall be of sufficient size to totally extinguish fire in the entire hazard area and prevent reignition of the fuel. [NFPA 96:14.7.11]

517.7.4 Listing/Class. All solid fuel appliances (whether or not under a hood) with fireboxes of 5 cubic feet (0.14 m³) volume or less shall have not less than a listed 2-A rated water-spray fire extinguisher or a 1.6 gallon (6.1 L) wet chemical fire extinguisher listed for Class K fires in accordance with NFPA 10 with a travel distance of not more than 20 feet (6096 mm) to the appliance. [NFPA 96:14.7.6, 14.7.7]

517.7.5 Fixed-Water Pipe System. Solid fuel appliances with fireboxes exceeding 5 cubic feet (0.14 m³) shall be provided with a fixed-water pipe system with a hose in the kitchen capable of reaching the firebox. The hose shall be equipped with an adjustable nozzle capable of producing a fine to medium spray or mist. The nozzle shall be of the type that cannot produce a straight stream. The system shall have an operating pressure of not less than 40 psi (276 kPa) and shall provide not less than 5 gallons per minute (gpm) (0.3 L/s). [NFPA 96:14.7.9.1 – 14.7.9.2]

517.7.6 Fuel Storage. Fuel storage areas shall be provided with a sprinkler system in accordance with the applicable requirements of this chapter. [NFPA 96:14.7.9.1]

517.8 Other Safety Requirements. Metal-fabricated solid-fuel cooking appliances shall be listed for the application where produced in practical quantities or shall be approved by the Authority Having Jurisdiction. Where listed, metal-fabricated solid fuel cooking appliances shall be installed in accordance with the terms of their listings and with the applicable requirements of this chapter. [NFPA 96:14.9.4.1, 14.9.4.2]

517.8.1 Site-Built Solid Fuel Cooling Appliances. Site-built solid-fuel cooking appliances shall be submitted for approval to the Authority Having Jurisdiction before being considered for installation. Units submitted to the Authority Having Jurisdiction shall be installed, operated, and maintained in accordance with the approved terms of the manufacturer’s instructions and additional requirements in accordance with the Authority Having Jurisdiction. [NFPA 96:14.9.4.3]

517.8.2 Additional Devices. Except for the spark arresters required in Section 517.7.6, there shall be no additional devices of any type in any portion of the appliance, flue pipe, and chimney of a natural draft solid-fuel operation. [NFPA 96:14.9.4.4]

517.8.3 Prohibited. No solid-fuel cooking device of any type shall be permitted for deep-fat frying involving more than 1 quart (qt) (1 L) of liquid shortening, and nor shall any solid-fuel cooking device shall not be permitted within 3 feet (914 mm) of a deep-fat frying unit. [NFPA 96:14.9.4.5]

518.0 Downdraft Appliances.

518.1 General. A downdraft appliance ventilation system containing, or for use with appliances used in processes that produce, smoke or grease-laden vapors shall be equipped with components that are in accordance with the following:

(1) The clearances requirements in accordance with Section 507.4.
(2) The primary collection means designed for collecting cooking vapors and residues in accordance with the requirements of Section 508.0.
(3) Grease removal devices that comply with Section 509.0.
(4) Special-purpose filters as listed in accordance with UL 1046.
(5) Exhaust ducts that comply with Section 510.0.
(6) The air movement requirements in accordance with Section 511.2.1 and Section 511.2.2.
(7) Auxiliary equipment (such as particulate and odor removal devices) are in accordance with Section 512.0.
(8) Fire-extinguishing equipment that in accordance with the requirements of Section 513.0, and as specified in Section 518.3.
(9) The use and maintenance requirements in accordance with Section 514.0.
(10) The minimum safety requirements in accordance with Section 515.0. [NFPA 96:15.1.1]
EXHAUST SYSTEMS

518.2 Ventilation System. The downdraft appliance ventilation system shall be capable of capturing and containing the effluent discharge from the appliance(s) it is serving. [NFPA 96:15.1.2]

518.3 Fire-Extinguishing Equipment. For fire-extinguishing equipment on a downdraft appliance ventilation system to comply with systems, the following shall apply:

1. Cooking surface, duct, and plenum protection shall be provided.

2. At least one fusible link or heat detector shall be installed within each exhaust duct opening in accordance with the manufacturer’s listing.

3. A fusible link or heat detector shall be provided above the protected cooking appliance and located in the plenum area of that appliance or in accordance with the extinguishing system manufacturer’s listing.

4. A manual activation device shall be provided as part of the each appliance at a height approved by the Authority Having Jurisdiction.

5. Portable fire extinguishers shall be installed in accordance with Section 513.11. [NFPA 96:15.2]

518.3.1 Integral Fire-Extinguishing System. A listed downdraft appliance ventilation system employing an integral fire-extinguishing system including detection systems that has been evaluated for grease and smoke capture, fire extinguishing, and detection shall be considered to be in accordance with Section 518.3. [NFPA 96:15.2.1]

518.3.2 Interlocks. The downdraft appliance ventilation system shall be provided with interlocks such that the cooking fuel supply will not be activated unless the exhaust and supply air system have been activated. [NFPA 96:15.2.2]

518.4 Airflow Switch or Transducer. An airflow switch or transducer shall be provided after the last filter component to ensure that a minimum airflow is maintained. [NFPA 96:15.3.1]

518.4.1 Interlocks. The airflow switch or transducer shall open the interlock circuit where the airflow is less than 25 percent of the system’s normal operating flow or less than 10 percent of its listed minimum rating, whichever is less. [NFPA 96:15.3.2]

518.4.2 Manual Reset. The airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:15.3.3]

518.5 Surface Materials. Surfaces located directly above the cooking appliance shall be of noncombustible or limited-combustible materials. [NFPA 96:15.4]

Exceptions:

1. Dishwashing machines connected to a Type II duct system and exhausted directly to the outdoors.

2. Dishwashing machines with a self-contained condensing system listed in accordance with UL 921 and installed in a space where the HVAC system has been engineered to accommodate the latent and sensible heat load emitted from such appliances as approved by the Authority Having Jurisdiction. Such equipment shall be provided with an interlocking device to prevent opening of the appliance prior to completion of its cycle.

519.2 Construction of Type II Hoods. Type II hoods constructed of steel shall be not less than 0.024 of an inch (0.61 mm) (No. 24 gauge). Hoods constructed of copper shall be of copper sheets weighing not less than 0.17 ounces per square inch (oz/in²) (7.47 kg/m²). Joints and seams shall be substantially tight. Solder shall not be used except for sealing a joint or seam.

519.3 Dishwashing Appliances. The net airflow for Type II hoods used for dishwashing equipment shall be not less than 200 cubic feet per minute (0.094 m³/s) per linear foot (m) of hood length.

519.4 Type II Exhaust Duct Systems. Ducts and plenums serving Type II hoods shall be constructed of rigid metallic materials in accordance with Chapter 6. Duct bracing and supports shall comply with Chapter 6. Ducts subject to positive pressure shall be adequately sealed.

519.5 Termination of Type II Hood Exhaust System. The exhaust system shall terminate as follows:

1. Rooftop terminations shall terminate not less than 10 feet (3048 mm) from a property line, and the exhaust flow shall be directed away from the roof surface of the roof, not less than 40 inches (1016 mm).

2. Horizontal terminations shall terminate not less than 10 feet (3048 mm) from adjacent buildings, property lines, operable openings, and from grade level.

3. The termination outlet shall not be directed onto a public way.

519.6 Makeup Air. Makeup air shall be provided in accordance with Section 511.3.
CHAPTER 6
DUCT SYSTEMS

601.0 General.
601.1 Applicability. Ducts and plenums that are portions of a heating, cooling, ventilation, or exhaust system shall comply with the requirements of this chapter.

601.2 Sizing Requirements. Duct systems shall be sized in accordance with applicable standards in Chapter 17 ACCA Manual D listed in Table 1701.1, or by other approved methods.

Exception: Residential duct systems shall be sized in accordance with ACCA Manual D listed in Table 1701.1, or by other approved methods.

602.0 Material.
602.1 General. Materials used for duct systems shall comply with Section 602.2 through Section 602.8 as applicable.

Concealed building spaces or independent construction within buildings shall be permitted to be used as ducts or plenums. Gypsum board shall not be used for positive pressure ducts.

Exception: In healthcare facilities, concealed spaces shall not be permitted to be used as ducts or plenums.

602.2 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. Plastic piping installed in plenums shall be tested in accordance with all requirements of 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.

Exceptions:
(1) Return-air and outside-air ducts, plenums, or concealed spaces that serve a dwelling unit.
(2) Air filters in accordance with the requirements of Section 311.2.
(3) Water evaporation media in an evaporative cooler.
(4) Charcoal filters where protected with an approved fire suppression system.
(5) Products listed and labeled for installation within plenums in accordance with Section 602.2.1 through Section 602.2.3.
(6) Smoke detectors.
(7) Duct insulation, coverings, and linings and other supplementary materials installed in accordance with Section 604.2.05.0.
(8) Materials in a hazardous fabrication area including the areas above and below the fabrication area sharing a common air recirculation path with the fabrication area.

602.2.1 Electrical. Electrical wiring in plenums shall comply with NFPA 70. Electrical wires and cables and optical fiber cables shall be listed and labeled for use in plenums and shall have a flame spread distance not exceeding 5 feet (1524 mm), an average optical density not exceeding 0.15, and a peak optical density not exceeding 0.5, where tested in accordance with NFPA 262.

602.2.2 Fire Sprinkler Piping. Nonmetallic fire sprinkler piping in plenums shall be listed and labeled for use in plenums and shall have a flame spread distance not exceeding 5 feet (1524 mm), an average optical density not exceeding 0.15 and, a peak optical density not exceeding 0.5, where tested in accordance with UL 1887.

602.2.3 Pneumatic Tubing. Nonmetallic pneumatic tubing in plenums shall be listed and labeled for use in plenums and shall have a flame spread distance not exceeding 5 feet (1524 mm), an average optical density not exceeding 0.15, and a peak optical density not exceeding 0.5, where tested in accordance with UL 1820.

602.2.4 Discrete Products in Plenums. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be listed and labeled in accordance with UL 2043.

602.3 Metallic. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Flexible metallic ducts shall comply with UL 181.

602.4 Nonmetallic Ducts. Nonmetallic ducts shall comply with Section 602.4.1, Section 602.4.2, Section 602.4.3 or Section 602.4.4.

602.4.4 Phenolic. Phenolic duct, plenum, or fitting material shall comply with UL 181. Ducts, plenums, or fittings of phenolic shall be constructed in accordance with SMACNA Phenolic Duct Construction Standards or the conditions of its listing.

602.5 Gypsum. Where gypsum products are exposed in ducts or plenums, the air temperature shall be restricted to a range from 50°F (10°C) to 125°F (52°C), and moisture content shall be controlled so that the material is not adversely affected. All gypsum products shall have a mold or mildew resistant surface. For the purpose of this section, gypsum products shall not be exposed in supply ducts.

602.4.3 Air Dispersion Systems. Air dispersion systems shall be listed and labeled in accordance with UL 2518.

602.4.4 Other Materials. Flexible and rigid ducts, plenums, or fittings for use in heating, ventilation, and air conditioning systems of other nonmetallic materials listed and labeled to UL 181 shall be permitted.
**Exception:** Plastic ducts shall comply with Section 603.5.

**602.6 Factory-Made Air Ducts.** Factory-made air ducts shall be approved for the use intended or shall be in accordance with the requirements of UL 181. Each portion of a factory-made air duct system shall be identified by the manufacturer with a label or other identification indicating compliance with its class designation.

**602.7** Vibration Isolators. Vibration isolation connectors installed between mechanical equipment and metal ducts (or casings) shall be made of an approved material and shall not exceed 10 inches (254 mm) in length.

**602.8 Corridors.** Corridors shall not be used to convey air to or from rooms where the corridor is required to be of fire-resistive construction in accordance with the building code except where permitted by the building code.

**603.0 Installation of Ducts.**

**603.1 General.** Air ducts shall be installed in accordance with this Chapter and the installation instructions. The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

**603.1.1 Pressure Classification.** The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

**603.1.2 Air Temperature.** The temperature of the air to be conveyed in a duct shall not exceed 250°F (121°C).

**603.1.3 Protection.** Air ducts, other than plastic ducts, shall be installed with not less than 4 inches (102 mm) of separation from earth, except where installed as a liner inside of concrete, tile, or metal pipe and shall be protected from physical damage.

**603.1.4 Vertical Risers.** Ducts listed and labeled to UL 181 shall not be used for vertical risers in air-duct systems serving more than two stories.

**603.1.5 Penetrations.** Ducts listed and labeled to UL 181 shall not penetrate a fire-resistance-rated assembly or structure.

**603.2 Under Floor or Crawl Space.** Air ducts installed under a floor in a crawl space shall be installed in accordance with the following:

1. Shall not prevent access to an area of the crawl space.
2. Where it is required to move under ducts for access to areas of the crawl space, a vertical clearance of not less than 18 inches (457 mm) shall be provided.

**603.3 Metal Ducts.** Ducts shall be supported at each change of direction and in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Riser ducts shall be held in place by means of metal straps or angles and channels to secure the riser to the structure.

**Flexible.** Ducts shall be installed with not less than 4 inches (102 mm) separation from earth. Ducts shall be installed in a building with clearances that will retain the full thickness of fireproofing on structural members.

**603.3.1 Earthquake Loads.** Ducts located in structures that are installed in areas classified as seismic design category C, D, E, or F shall be in accordance with the building code.

**603.4 Factory-Made Air Ducts.** Factory-made air ducts shall be listed and labeled in accordance with UL 181 and installed in accordance with the terms of their listing, the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Exception: Residential occupancies.

**603.3.4 Flexible Air Ducts.** Flexible air ducts shall comply with UL 181, and shall be installed in accordance with the manufacturer’s installation instructions and SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Flexible air duct installations shall comply with the following:

1. Ducts shall be installed using the minimum required length to make the connection.
2. Horizontal duct runs shall be supported at not more than 4 feet (1219 mm) intervals.
3. Vertical risers shall be supported at not more than 6 feet (1829 mm) intervals.
4. Sag between support hangers shall not exceed ½ inch (12.7 mm) per foot (305 mm) of support spacing.
5. Supports shall be rigid and shall be not less than 1½ inches (38 mm) wide at point of contact with the duct surface.
6. Duct bends shall be not less than one duct diameter bend radius.
7. Screws shall not penetrate the inner liner of non-metallic flexible ducts unless permitted in accordance with the manufacturer’s installation instructions.
8. Fittings for attaching non-metallic ducts shall be beaded and have a collar length of not less than 2 inches (51 mm) for attaching the duct. Metal worm-gear clamps shall be used.
603.7.1 Flexible Air Ducts. Flexible air ducts shall be sealed in accordance with Section 603.4.2, Section 603.4.3, or Section 603.4.4. Flexible air ducts shall be supported in accordance with Sections 603.3.1 or 603.3.2. Flexible air ducts shall be used in accordance with the manufacturer’s installation instructions. Other ducts shall comply with Sections 603.3.1 or 603.3.2. Flexible air ducts shall be supported in accordance with the manufacturer’s instructions. Other approved ducts shall be supported in accordance with Section 603.4.

603.7.2 Flexible Air Connectors. Flexible air connectors shall not be permitted. Exception: Residential occupancies.

603.7.3 Other Ducts. Other approved ducts shall be supported in accordance with the manufacturer’s installation instructions. Factory-made air ducts that are in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Other ducts shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Ducts shall be supported in accordance with the manufacturer’s installation instructions and Section 603.7.1, Section 603.7.2, or Section 603.7.3.

603.7.4 Support of Ducts. Installers shall provide the manufacturer’s field fabrication and installation instructions. Factory-made air ducts that are in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Other ducts shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Ducts shall be supported in accordance with the manufacturer’s installation instructions and Section 603.7.1, Section 603.7.2, or Section 603.7.3.

603.7.5 Plastic Ducts. Plastic air ducts and fittings shall be permitted where installed underground and listed for such use.

603.7.6 Protection of Ducts. Ducts installed in locations where they are exposed to mechanical damage by vehicles or from other causes shall be protected by approved barriers.

603.7.7 Support of Ducts. Installers shall provide the manufacturer’s field fabrication and installation instructions. Factory-made air ducts that are in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Other ducts shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Ducts shall be supported in accordance with the manufacturer’s installation instructions and Section 603.7.1, Section 603.7.2, or Section 603.7.3.

603.7.8 Protection Against Flood Damage. In flood hazard areas, ducts shall be located above the elevation required by the building code for utilities and attendant equipment or the elevation of the lowest floor, whichever is higher, or shall be designed and constructed to prevent water from entering or accumulating within the ducts during floods up to such elevation. Where the ducts are located below that elevation, the ducts shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to such elevation.

603.7.9 Joints and Seams of Ducts. Joints and seams for duct systems shall comply with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Joints of duct systems shall be made substantially airtight by means of tapes, mastics, gasketing, or other means. Crimp joints for round ducts shall have a contact lap of not less than 1 1/2 inches (38 mm) and shall be mechanically fastened by means of not less than three sheet-metal screws equally spaced around the joint, or an equivalent fastening method.

603.7.10 Closure Systems. Joints and seams and reinforcements for factory-made air ducts and plenums listed and labeled to UL 181 shall comply with the conditions of prior approval in accordance with the manufacturer’s installation instructions that shall accompany the product. Closure systems for sealing factory-made ducts and plenums shall be listed and labeled in accordance with UL 181A or UL 181B, and marked in accordance with Table 603.10.
603.10 Duct Leakage Tests. Ductwork shall be leak-tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual. Representative sections totalizing not less than 10 percent of the total installed duct area shall be tested. Where the tested 10 percent fail to comply with the requirements of this section, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fail to comply with the requirements of this section, then 100 percent of the total installed duct area shall be tested. Sections shall be selected by the building owner or designated representative of the building owner. Positive pressure testing shall be permitted for negative pressure ductwork. The permitted duct leakage shall be not more than the following:

\[ L_{\text{max}} = C_L P^{0.65} \]

(Equation 603.10-603.9.2)

Where:

- \( L_{\text{max}} \) = maximum permitted leakage, \((\text{ft}^3/\text{min})/100\text{ square feet} [0.0001 \text{ m}^3/\text{s}]/\text{m}^2\) duct surface area.
- \( C_L \) = six, duct leakage class, \((\text{ft}^3/\text{min})/100\text{ square feet} [0.0001 \text{ m}^3/\text{s}]/\text{m}^2\) duct surface area at 1 inch water column (0.2 kPa).
- \( P \) = test pressure, which shall be equal to the design duct pressure class rating, inch water column (kPa).

603.11 Cross Contamination. Exhaust ducts that convey Class 4 air shall be negatively pressurized relative to ducts, plenums, or occupiable spaces through which the ducts pass. Exhaust ducts and venting systems under positive pressure that convey Class 2 or Class 3 air shall not extend into or pass through ducts, or plenums, or occupiable spaces other than the space from which the exhaust air is drawn.

**Exception:** Exhaust ducts conveying Class 2 air and exhaust ducts conveying air from residential kitchen hoods that are sealed in accordance with SMACNA Seal Class A. [ASHRAE 62.1:5.2.1, 5.2.2].

603.12 Underground Installation. Ducts installed underground shall be approved for the installation and shall have a slope of not less than \(\frac{1}{8}\) inch per foot (10.4 mm/m) back to the main riser. Ducts, plenums, and fittings shall be permitted to be constructed of concrete, clay, or ceramics where installed in the ground or in a concrete slab, provided the joints are sealed and duct is secured in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible. Metal ducts where installed in or under a concrete slab shall be encased in not less than 2 inches (51 mm) of concrete, secured in accordance with SMACNA HVAC Duct Construction Standards–Metal and Flexible.

603.13 Air Dispersion Systems. Where installed, air dispersion systems shall be completely in exposed locations in duct systems under positive pressure, and not pass through or penetrate fire-resistant-rated construction. Air dispersion systems shall be listed and labeled in accordance with UL 2518.

**603.13 Clearances.** Duct clearances shall be in accordance with Section 603.13.1 through Section 603.13.6.

603.13.1 General. Duct clearances to combustible construction shall be in accordance with the listing and the manufacturer’s installation instructions.

604.2 Supply Air Ducts To Listed Furnaces. Supply air ducts connecting to listed central heating furnaces shall have the same minimum clearance to combustibles as required for the furnace supply plenum for a distance of not less than 6 feet (1829 mm) from the supply plenum. Clearance shall not be required beyond the 6 feet (1829 mm) distance. [NFPA 54:10.3.2.8]

604.2.2 Supply Air Ducts To Unlisted Furnaces. Supply air ducts connecting to unlisted central heating furnaces equipped with temperature limit controls with a maximum setting of 250°F (121°C) shall have a minimum clearance to combustibles of 6 inches (152 mm) for a distance of not less than 6 feet (1829 mm) from the furnace supply plenum. Clearance shall not be required beyond the 6 feet (1829 mm) distance. [NFPA 54:10.3.2.8]

604.2.5 Furnace Plenums and Air Ducts. A furnace plenum supplied as a part of the air-conditioning appliance shall be installed in accordance with the manufacturer’s instructions. Where a furnace plenum is not supplied with the appliance, any fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate proper circulation of air. Where the air conditioner is installed within an enclosure, the installation shall comply with Section 904.7. [NFPA 54:10.2.5]

603.13.5 Duct Furnaces. Duct Furnaces shall be installed in accordance with Section 905.0.
604.0 Furnace Plenums and Ducts Used in Fuel-Gas Appliances.

604.4.1 Furnace Plenums and Air Ducts. Furnace plenums and air ducts shall be installed in accordance with this Chapter; and NFPA 90A or NFPA 90B—[NFPA 54:10.3.7.1]

604.4.604.2 Supplied As a Part of Furnace. A furnace plenum supplied as a part of a furnace shall be installed in accordance with the manufacturer’s instructions. [NFPA 54:10.3.7.2]

604.4.3 Not Supplied With The Furnace. Where a furnace plenum is not supplied with the furnace, any fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate proper circulation of air. [NFPA 54:10.3.7.3]

604.4.604.4 Return Air. Where a furnace is installed so that supply ducts carry air circulated by the furnace to areas outside the space containing the furnace, the return air shall also be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace. [NFPA 54:10.3.7.4]

604.605.0 Insulation of Ducts.

604.605.1 General. Air ducts conveying air at temperatures exceeding 140°F (60°C) shall be insulated to maintain an insulation surface temperature of not more than 140°F (60°C). Factory made air ducts and insulations intended for installation insulation material on the exterior of ducts shall be legibly printed with the name of the manufacturer, the thermal resistance (R) value at installed thickness, flame-spread index, and smoke developed index of the composite material. Internal duct liners and insulation shall be installed in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.

Exceptions:

1. Factory-installed plenums, casings, or ductwork furnished as a part of HVAC equipment tested and rated in accordance with approved energy efficiency standards.

2. Ducts or plenums located in conditioned spaces where heat gain or heat loss will not increase energy use.

3. For runouts less than 10 feet (3048 mm) in length to air terminals or air outlets, the rated R-value of insulation need not exceed R-3.5.

4. Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas exceeding 5 square feet (0.5 m²) need not exceed R-2; those 5 square feet (0.5 m²) or smaller need not be insulated.

5. Ducts and plenums used exclusively for evaporative cooling systems.

604.4.605.1 Within Ducts or Plenums. Materials installed within ducts and plenums for insulating, sound deadening, or other purposes shall have a mold, humidity, and erosion-resistant surface where tested in accordance with UL 181. Duct liners in systems operating with air velocities exceeding 2000 feet per minute (10.16 m/s) shall be fastened with both adhesive and mechanical fasteners, and exposed edges shall have approved treatment to withstand the operating velocity. Where the internal insulation is capable of being in contact with condensates or other liquids, the material shall be water-resistant. Pipe and duct insulation shall not be used to reduce the maximum flame and smoke requirements in Section 602.2 unless tested in accordance with ASTM E84 or UL 723 as a composite assembly of the duct or pipe and its associated insulation, coatings and adhesives.

604.4.605.2 Duct Coverings and Linings. Insulation applied to the surface of ducts, including duct coverings, linings, tapes, and adhesives, located in buildings 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. The specimen preparation and mounting procedures of ASTM E2231 shall be used. Air duct coverings and linings shall not be flame, glow, smolder, or smoke where tested in accordance with ASTM C411 at the temperature to which they are exposed in service. In no case shall the test temperature be less than 250°F (121°C). Coverings shall not penetrate a fire-resistance-rated assembly.
**605.4606.4 Multiple Arrangements.** Where size requires the use of multiple dampers, each damper shall be listed for use in multiple arrangements and installed in accordance with the manufacturer's installation instructions.

**605.5606.5 Access and Identification.** Fire and smoke dampers shall be provided with an approved means of access large enough to allow inspection and maintenance of the damper and its operating parts. The access shall not affect the integrity of the fire-resistance-rated assembly. The access openings shall not reduce the fire-resistance rating of the assembly.

Access shall not require the use of tools. Access doors in ducts shall be tight fitting and approved for the required duct construction. Access points shall be permanently identified on the exterior by a label with letters not less than 1/2 of an inch (12.7 mm) in height reading as one of the following:

1. Smoke Damper
2. Fire Damper
3. Fire/Smoke Damper

**605.6606.6 Freedom from Interference.** Dampers shall be installed in a manner to ensure positive closing or opening as required by function. Interior liniers or insulation shall be held back from portions of a damper, its sleeve, or adjoining duct that would interfere with the damper's proper operation. Exterior materials shall be installed so as not to interfere with the operation or maintenance of external operating devices needed for the function of the damper.

**605.7606.7 Temperature Classification of Operating Elements.** Fusible links, thermal sensors, and pneumatic or electric operators shall have a temperature rating or classification as in accordance with the building code.

**606.0607.0 Ventilating Ceilings.**

**606.1607.1 General.** Perforated ceilings shall be permitted to be used for air supply within the limitations of this section. Exit corridors, where required to be of fire-resistive construction by the building code, shall not have ventilating ceilings.

**606.2607.2 Requirements.** Ventilating ceilings shall comply with the following:

1. Suspended ventilating ceiling material shall have a Class 1 flame spread classification on both sides, determined in accordance with the building code. Suspended ventilating ceiling supports shall be of noncombustible materials.
2. Lighting fixtures recessed into ventilating ceilings shall be of a type approved for that purpose.

**607.9608.0 Use of Under-Floor Space as Supply Plenum for Dwelling Units.**

**607.1608.1 General.** An under-floor space shall be permitted to be used as a supply plenum.

**607.2608.2 Dwelling Units.** The use of under-floor space shall be limited to dwelling units not more than two stories in height. Except for the floor immediately above the under-floor plenum, supply ducts shall be provided extending from the plenum to registers on other floor levels.

**Exception:** In flood hazard areas, under-floor spaces shall not be used as supply plenums unless the flood opening requirements in the building code are met.

**607.3608.3 Enclosed.** Such spaces shall be cleaned of all loose combustible scrap material and shall be tightly enclosed.

**607.4608.4 Flammable Materials.** The enclosing material of the under-floor space, including the sidewall insulation, shall be not more flammable than 1 inch (25.4 mm) (nominal) wood boards (flame-spread index of 200). Installation of foam plastics is regulated by the building code.

**607.5608.5 Access.** Access shall be through an opening in the floor and shall be not less than 24 inches by 24 inches (610 mm by 610 mm).

**607.6608.6 Automatic Control.** A furnace supplying warm air to under-floor space shall be equipped with an automatic control that will start the air-circulating fan when the air in the furnace bonnet reaches a temperature not exceeding 150°F (66°C). Such control shall be one that cannot be set to exceed 150°F (66°C).

**607.7608.7 Temperature Limit.** A furnace supplying warm air to such space shall be equipped with an approved temperature limit control that will limit outlet air temperature to 200°F (93°C).

**607.8608.8 Noncombustible Receptacle.** A noncombustible receptacle shall be placed below each floor opening into the air chamber, and such receptacle shall comply with Section 607.8.1 through Section 607.8.3.

**607.8.1 Location.** The receptacle shall be securely suspended from the floor members and shall be not more than 18 inches (457 mm) below the floor opening.

**607.8.2 Area.** The area of the receptacle shall extend 3 inches (76 mm) beyond the opening on all sides.

**607.8.3 Perimeter.** The perimeter of the receptacle shall have a vertical lip not less than 1 inch (25.4 mm) high at the open sides where it is at the level of the bottom of the joists, or 3 inches (76 mm) high where the receptacle is suspended.

**607.9608.9 Floor Registers.** Floor registers shall be designed for easy removal in order to give access for cleaning the receptacles.

**607.10608.10 Exterior Wall and Interior Stud Partitions.** Exterior walls and interior stud partitions shall be fire blocked at the floor.

**607.11608.11 Wall Register.** Each wall register shall be connected to the air chamber by a register box or boot.

**607.12608.12 Distance from Combustible.** A duct complying with Section 602.0 shall extend from the furnace supply outlet not less than 6 inches (152 mm) below combustible framing.

**607.13608.13 Vapor Barrier.** The entire ground surface of the under-floor space shall be covered with a vapor barrier having a thickness not less than 4 mils (0.1 mm) and a flame-spread index of not more than 200.
607.14608.14 Prohibited. Fuel gas lines and plumbing waste cleanouts shall not be located within the space.

608.0509.0 Automatic Shutoffs.

608.14609.1 Air-Moving Systems and Smoke Detectors. Air-moving systems supplying air in excess of 2000 cubic feet per minute (ft³/min) (0.9439 m³/s) to enclosed spaces within buildings shall be equipped with an automatic shutoff. Automatic shutoff shall be accomplished by interrupting the power source of the air-moving equipment upon detection of smoke in the main supply-air duct served by such equipment. Duct smoke detectors shall comply with UL 268A and shall be installed in accordance with the manufacturer’s installation instructions. Such devices shall be compatible with the operating velocities, pressures, temperatures, and humidities of the system. Where fire-detection or alarm systems are provided for the building, the smoke detectors shall be supervised by such systems in an approved manner.

Exceptions:
(1) Where the space supplied by the air-moving equipment is served by a total coverage smoke-detection system in accordance with the fire code, interconnection to such system shall be permitted to be used to accomplish the required shutoff.
(2) Automatic shutoff is not required where occupied rooms served by the air-handling equipment have direct exit to the exterior, and the travel distance does not exceed 100 feet (30 480 mm).
(3) Automatic shutoff is not required for Group R, Division 3 and Group U Occupancies.
(4) Automatic shutoff is not required for approved smoke-control systems or where analysis demonstrates shutoff would create a greater hazard, such as shall be permitted to be encountered in air-moving equipment supplying specialized portions of Group H Occupancies. Such equipment shall be required to have smoke detection with remote indication and manual shutoff capability at an approved location.
(5) Smoke detectors that are factory installed in listed air-moving equipment shall be permitted to be used in lieu of smoke detectors installed in the main supply-air duct served by such equipment.
CHAPTER 7
COMBUSTION AIR

701.0 General.

701.1 Applicability. Air for combustion, ventilation, and dilution of flue gases for appliances installed in buildings shall be obtained by application of one of the methods covered in Section 701.4 through Section 701.9.3. Where the requirements of Section 701.4 are not met, outdoor air shall be introduced in accordance with methods covered in Section 701.6 through Section 701.9.3.

Exceptions:
(1) This provision shall not apply to direct-vent appliances.
(2) Type 1 clothes dryers that are provided with makeup air in accordance with Section 504.4.1(1). [NFPA 54:9.3.1.1]

701.1.1 Other Types of Appliances. Appliances of other than natural draft design, appliances not designated as Category I vented appliances, and appliances equipped with power burners shall be provided with combustion, ventilation, and dilution air in accordance with the appliance manufacturer’s instructions. [NFPA 54:9.3.1.2]

701.2 Pressure Difference. Where used, a draft hood or a barometric draft regulator shall be installed in the same room or enclosure as the appliance served so as to prevent a difference in pressure between the hood or regulator and the combustion-air supply. [NFPA 54:9.3.1.4]

701.3 Makeup Air. Where exhaust fans, clothes dryers, and kitchen ventilation systems interfere with the operation of appliances, makeup air shall be provided. [NFPA 54:9.3.1.5]

701.4 Indoor Combustion Air. The required volume of indoor air shall be determined in accordance with the method in Section 701.4.1 or Section 701.4.2, except that where the air infiltration rate is known to be less than 0.40 ACH (air change per hour), the method in Section 701.4.2 shall be used. The total required volume shall be the sum of the required volume calculated for appliances located within the space. Rooms communicating directly with the space in which the appliances are installed through openings not furnished with doors, and through combustion air openings sized and located in accordance with Section 701.5, are considered a part of the required volume. [NFPA 54:9.3.2]

701.4.1 Standard Method. The required volume shall be not less than 50 cubic feet per 1000 British thermal units per hour (Btu/h) (4.83 m³/kW). [NFPA 54:9.3.2.1]

701.4.2 Known Air Infiltration Rate Method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows [NFPA 54:9.3.2.2]:
(1) For appliances other than fan-assisted, calculate using the following Equation 701.4.2(1). [NFPA 54:9.3.2.2(1)]
(2) For fan-assisted appliances, calculate using the following Equation 701.4.2(2). [NFPA 54: 9.3.2.2(2)]

(3) For purposes of these calculations, an infiltration rate greater than 0.60 ACH shall not be used in the equations in Section 701.4.2(1) and Section 701.4.2(2). [NFPA 54:9.3.2.2(3)]

[Equation 701.4.2(1)]

\[
\text{Required Volume}_{\text{other}} \geq (21 \text{ ft}^3/\text{ACH}) \times (I_{\text{other}}/1000 \text{ Btu/h})
\]

[Equation 701.4.2(2)]

\[
\text{Required Volume}_{\text{fan}} \geq (15 \text{ ft}^3/\text{ACH}) \times (I_{\text{fan}}/1000 \text{ Btu/h})
\]

Where:
\[
I_{\text{other}} = \text{All appliances other than fan-assisted input (Btu/h)}
\]
\[
I_{\text{fan}} = \text{Fan-assisted appliance input (Btu/h)}
\]
\[
\text{ACH} = \text{Air change per hour (percent of volume of space exchanged per hour, expressed as a decimal)}
\]

For SI units: 1 cubic foot = 0.0283 m³, 1000 British thermal units per hour = 0.293 kW

701.5 Indoor Opening Size and Location. Openings used to connect indoor spaces shall be sized and located in accordance with the following:
(1) Combining spaces on the same story. Each opening shall have a minimum free area of not less than 1 square inch per 1000 Btu/h (0.002 m²/kW) of the total input rating of all appliances in the space, but not less than 100 square inches (0.065 m²). One permanent opening shall commence within 12 inches (305 mm) of the top of the enclosure, and one permanent opening shall commence within 12 inches (305 mm) of the bottom of the enclosure (see Figure 701.5). The minimum dimension of air openings shall not be less than 3 inches (76 mm).

(2) Combining spaces in different stories. The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are connected by one or more permanent openings in doors or floors having a total minimum free area of not less than 2 square inches per 1000 Btu/h (0.004 m²/kW) of total input rating of all appliances. [NFPA 54:9.3.2.3]

701.6 Outdoor Combustion Air. Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with the methods in Section 701.6.1 or Section 701.6.2. The dimension of air openings shall be not less than 3 inches (76 mm). [NFPA 54:9.3.3]

701.6.1 Two Permanent Openings Method. Two permanent openings, one commencing within 12 inches (305 mm) of the top of the enclosure and one commencing within 12 inches (305 mm) of the bottom of the enclosure, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors or spaces that freely communicate with the outdoors as follows:
FIGURE 701.5
COMBUSTION AIR FROM ADJACENT INDOOR SPACES THROUGH INDOOR COMBUSTION AIR OPENINGS
[NFPA 54: FIGURE A.9.3.2.3(1)]

(1) Where directly communicating with the outdoors or where communicating to the outdoors through vertical ducts, each opening shall have a free area of not less than 1 square inch per 4000 Btu/h (0.0005 m²/kW) of total input rating of appliances in the enclosure. [See Figure 701.6.1(1) and Figure 701.6.1(2)]

(2) Where communicating with the outdoors through horizontal ducts, each opening shall have a free area of not less than 1 square inch per 2000 Btu/h (0.001 m²/kW) of total input rating of appliances in the enclosure. [See Figure 701.6.1(3)] [NFPA 54:9.3.3.1]

701.6.2 One Permanent Opening Method. One permanent opening, commencing within 12 inches (305 mm) of the top of the enclosure, shall be provided. The appliance shall have clearances of at least 1 inch (25.4 mm) from the sides and back and 6 inches (152 mm) from the front of the appliance. The opening shall directly communicate with the outdoors or shall communicate through a vertical or horizontal duct to the outdoors or spaces that freely communicate with the outdoors (see Figure 701.6.2) and shall have a minimum free area of the following:

(1) One square inch per 3000 Btu/h (0.0007 m²/kW) of the total input rating of all appliances located in the enclosure.

(2) Not less than the sum of the areas of all vent connectors in the space. [NFPA 54:9.3.3.2]

701.7 Combination Indoor and Outdoor Combustion Air. The use of a combination of indoor and outdoor combustion air shall be in accordance with Section 701.7.1 through Section 701.7.3. [NFPA 54:9.3.4] (see Appendix F for example calculations)

701.7.1 Indoor Openings. Where used, openings connecting the interior spaces shall be in accordance with Section 701.5. [NFPA 54:9.3.4(1)]
701.7.2 Outdoor Openings. Outdoor openings shall be located in accordance with Section 701.6. [NFPA 54: 9.3.4(2)]

701.7.3 Outdoor Opening(s) Size. The outdoor opening(s) size shall be calculated in accordance with the following:
   (1) The ratio of the interior spaces shall be the available volume of all communicating spaces divided by the required volume.
   (2) The outdoor size reduction factor shall be \(1 - \frac{1}{\text{ratio of interior spaces}}\).
   (3) The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with Section 701.6, multiplied by the reduction factor. The minimum dimension of air openings shall not be less than 3 inches (76 mm). [NFPA 54:9.3.4(3)]

701.8 Engineered Installations. Engineered combustion air installations shall provide an adequate supply of combustion, ventilation, and dilution air and shall be approved by the Authority Having Jurisdiction. [NFPA 54:9.3.5]

701.9 Mechanical Combustion Air Supply. Where combustion air is provided by a mechanical air supply system, the combustion air shall be supplied from outdoors at the rate of not less than 0.35 cubic feet per minute per 1000 Btu/h [0.034 (m³/min)/kW] for appliances located within the space. [NFPA 54:9.3.6]

701.9.1 Exhaust Fans. Where exhaust fans are installed, additional air shall be provided to replace the exhausted air. [NFPA 54:9.3.6.1]

701.9.2 Interlock. Each of the appliances served shall be interlocked to the mechanical air supply system to prevent main burner operation where the mechanical air supply system is not in operation. [NFPA 54:9.3.6.2]

701.9.3 Specified Combustion Air. Where combustion air is provided by the building’s mechanical ventilation system, the system shall provide the specified combustion air rate in addition to the required ventilation air. [NFPA 54:9.3.6.3]

701.10 Louvers, Grilles, and Screens. The required size of openings for combustion, ventilation, and dilution air shall be based on the net free area of each opening. Where the free area through a design of louver, grille, or screen is known, it shall be used in calculating the size opening required to provide the free area specified. Where the louver and grille design and free area are not known, it shall be assumed that wood louvers have 25 percent free area and metal louvers and grilles have 75 percent free area. Nonmotorized louvers and grilles shall be fixed in the open position. [NFPA 54:9.3.7.1]

701.10.1 Minimum Screen Mesh Size. Screens shall be not less than \(\frac{1}{4}\) of an inch (6.4 mm) mesh. [NFPA 54:9.3.7.2]

701.10.2 Motorized Louvers. Motorized louvers shall be interlocked with the appliance so they are proven in the full open position prior to main burner ignition and during main burner operation. Means shall be provided to prevent the main burner from igniting where the louver fail to open during burner start-up and to shut down the main burner where the louvers close during burner operation. [NFPA 54:9.3.7.3]
701.11 Combustion Air Ducts. Combustion air ducts shall comply with the following [NFPA 54:9.3.8]:

(1) Ducts shall be constructed of galvanized steel or a material having equivalent corrosion resistance, strength, and rigidity.

   Exception: Within dwellings units, unobstructed stud and joist spaces shall not be prohibited from conveying combustion air, provided that not more than one fireblock is removed. [NFPA 54:9.3.8.1]

(2) Ducts shall terminate in an unobstructed space, allowing free movement of combustion air to the appliances. [NFPA 54:9.3.8.2]

(3) Ducts shall serve a single space. [NFPA 54:9.3.8.3]

(4) Ducts shall not serve both upper and lower combustion air openings where both such openings are used. The separation between ducts serving upper and lower combustion air openings shall be maintained to the source of combustion air. [NFPA 54:9.3.8.4]

(5) Ducts shall not be screened where terminating in an attic space. [NFPA 54:9.3.8.5]

(6) Combustion air intake openings located on the exterior of the building shall have the lowest side of the combustion air intake openings located at least 12 inches (305 mm) vertically from the adjoining finished ground level. [NFPA 54:9.3.8.8]

(7) Horizontal upper combustion air ducts shall not slope downward toward the source of combustion air. [NFPA 54:9.3.8.6]

(8) The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry, metal, or factory-built chimney shall not be used to supply combustion air.

   Exception: Direct-vent appliances designed for installation in a solid fuel-burning fireplace where installed in accordance with the manufacturer’s installation instructions. [NFPA 54:9.3.8.7]

701.12 Dampers Prohibited. Combustion air ducts or plenums shall not be installed so as to require openings in or penetrations through construction where fire dampers are required. Manually operated dampers shall not be installed in combustion air openings. With prior approval, power-actuated movable louvers admitting combustion air shall be permitted to be used and, where installed, shall be electrically interlocked with the main burner fuel-supply valve so as to prevent fuel delivery unless the louvers are in the fully open position.

702.0 Extra Device or Attachment.

702.1 General. No device or attachment shall be installed on any appliance that could in any way impair the combustion of gas. [NFPA 54:9.1.15]
CHAPTER 8
CHIMNEYS AND VENTS

801.0 General.
801.1 Applicability. The requirements of this chapter shall govern the venting of fuel-burning appliances.

801.2 Venting of Gas Appliances. Low-heat and medium-heat gas appliances shall be vented in accordance with this chapter. Other gas appliances shall be vented in accordance with NFPA 211 or other applicable standards.

801.3 Appliances Fueled by Other Fuels. Appliances fueled by fuels other than gas shall be vented in accordance with NFPA 211 and the appliance manufacturer’s instructions.

802.0 Venting of Appliances.
802.1 Listing. Type B and Type B-W gas vents shall comply with UL 441, Type L gas vents shall comply with UL 641.

802.1.1 Installation. Listed vents shall be installed in accordance with this chapter and the manufacturer’s installation instructions. [NFPA 54:12.2.1]

802.1.2 Prohibited Discharge. Appliance vents shall not discharge into a space enclosed by screens having openings less than ¼ of an inch (6.4 mm) mesh.

802.2 Connection to Venting Systems. Except as permitted in Section 802.2.1 through Section 802.2.8, all appliances shall be connected to venting systems. [NFPA 54:12.3.1]

802.2.1 Appliances Not Required to be Ventted. The following appliances shall not be required to be vented:

1. Listed ranges.
2. Built-in domestic cooking units listed and marked for optional venting.
3. Listed hot plates and listed laundry stoves.
4. Listed Type 1 clothes dryers exhausted in accordance with Section 504.4.
5. A single listed booster-type (automatic instantaneous) water heater, when designed and used solely for the sanitizing rinse requirements of a dishwashing machine, provided that the appliance is installed with the draft hood in place and unaltered, if a draft hood is required, in a commercial kitchen having a mechanical exhaust system, where installed in this manner, the draft hood outlet shall not be less than 36 inches (914 mm) vertically and 6 inches (152 mm) horizontally from any surface other than the appliance.
7. Counter appliances.
8. Room heaters listed for unvented use.
10. Other appliances listed for unvented use and not provided with flue collars.

802.2.2 Maximum Input Rating. Where any or all of the appliances in Section 802.2.1(5) through Section 802.2.1(11) are installed so the aggregate input rating exceeds 20 Btu/hr/ft³ (207 W/m³) room or space in which it is installed, one or more shall be provided with venting systems or other approved means for conveying the vent gases to the outdoors so the aggregate input rating of the remaining unvented appliances does not exceed 20 Btu/hr/ft³ (207 W/m³). [NFPA 54:12.3.2.1]

802.2.3 Adjacent Room or Space. Where the calculation includes the volume of an adjacent room or space, the room or space in which the appliances are installed shall be directly connected to the adjacent room or space by a doorway, archway, or other opening of comparable size that cannot be closed. [NFPA 54:12.3.2.2]

802.2.4 Ventilating Hoods. The use of ventilating hoods and exhaust systems shall be permitted to be used for vent appliances shall be limited to industrial appliances and appliances installed in commercial applications and to vent industrial appliances, particularly where the process itself requires fume disposal. [NFPA 54:12.3.3]

802.2.5 Well-Ventilated Spaces. The operation of flue gases from industrial-type appliances shall not be required to be vented to the outdoors where such flue gases are discharged directly into a large and well-ventilated industrial space shall be permitted. [NFPA 54:12.3.4]

802.2.6 Direct-Vent Appliances. Listed direct-vent appliances shall be installed in accordance with the manufacturer’s installation instructions and Section 802.8.2. [NFPA 54:12.3.5]

802.2.7 Appliances with Integral Vents. Appliances incorporating integral venting means shall be installed in accordance with the manufacturer’s installation instructions, Section 802.8, and Section 802.8.1. [NFPA 54:12.3.6]

802.2.8 Incinerators, Commercial–Industrial. Commercial industrial-type incinerators shall be vented in accordance with NFPA 82. [NFPA 54:12.3.7]

802.3 Design and Construction Minimum Safe Performance. Venting systems shall be designed and constructed to convey all flue and vent gases to the outdoors. [NFPA 54:12.1]

802.3.1 Appliance Draft Requirements. A venting system shall satisfy the draft requirements of the appliance in accordance with the manufacturer’s instructions. [NFPA 54:12.4.1]

802.3.2 Appliance Venting Requirements. Appliances required to be vented shall be connected to a venting system designed and installed in accordance with the provisions of Section 802.4 through Section 802.15.1. [NFPA 54:12.4.2]
802.3.3 Mechanical Draft Systems. Mechanical draft systems shall be listed in accordance with UL 378 and installed in accordance with both the appliance and the mechanical draft system manufacturer’s installation instructions. [NFPA 54:12.4.3.1]

802.3.3.1 Venting. Appliances requiring venting shall be permitted to be vented by means of mechanical draft systems of either forced or induced draft design. [NFPA 54:12.4.3.2]

802.3.3.2 Leakage. Forced draft systems and all portions of induced draft systems under positive pressure during operation shall be designed and installed so as to prevent leakage of flue or vent gases into a building. [NFPA 54:12.4.3.3]

802.3.3.3 Vent Connectors. Vent connectors serving appliances vented by natural draft shall not be connected into any portion of mechanical draft systems operating under positive pressure. [NFPA 54:12.4.3.4]

802.3.3.4 Operation. Where a mechanical draft system is employed, provision shall be made to prevent the flow of gas to the main burners when the draft system is not performing so as to satisfy the operating requirements of the appliance for safe performance. [NFPA 54:12.4.3.5]

802.3.3.5 Exit Terminals. The exit terminals of mechanical draft systems shall be not less than 7 feet (2134 mm) above finished ground level where located adjacent to public walkways and shall be located as specified in Section 802.8 and Section 802.8.1. [NFPA 54:12.4.3.6]

802.3.4 Ventilating Hoods and Exhaust Systems. Ventilating hoods and exhaust systems shall be permitted to be used to vent appliances installed in commercial applications. [NFPA 54:12.4.4.1]

802.3.4.1 Automatically Operated Appliances. Where automatically operated appliances, other than commercial cooking appliances, are vented through a ventilating hood or exhaust system equipped with a damper or with a power means of exhaust, provisions shall be made to allow the flow of gas to the main burners when the damper is open to a position to properly vent the appliance and when the power means of exhaust is in operation. [NFPA 54:12.4.4.2]

802.3.5 Circulating Air Ducts, Above-Ceiling Air-Handling Spaces, and Furnace Plenums. Venting systems shall not extend into or pass through any fabricated air duct or furnace plenum. [NFPA 54:12.4.5.1]

802.3.6 Above-Ceiling or Nonducted Air Handling System. Where a venting system passes through an above-ceiling air space or other nonducted portion of an air-handling system, it shall conform to one of the following requirements:

1. The venting system shall be a listed special gas vent, other system serving a Category III or Category IV appliance, or other positive pressure vent, with joints sealed in accordance with the appliance or vent manufacturer’s instructions.

(2) The vent system shall be installed such that no fittings or joints between sections are installed in the above-ceiling space.

(3) The venting system shall be installed in a conduit or enclosure with joints between the interior of the enclosure and the ceiling space sealed. [NFPA 54:12.4.5.2]

802.4 Type of Venting System to be Used. The type of venting system to be used shall be in accordance with Table 802.4. [NFPA 54:12.5.1]

802.4.1 Plastic Piping. Where plastic piping is used to vent an appliance, the appliance shall be listed for use with such venting materials and the appliance manufacturer’s installation instructions shall identify the specific plastic piping material. The plastic pipe venting materials shall be labeled in accordance with the product standards specified by the appliance manufacturer or shall be listed and labeled in accordance with UL 1738. [NFPA 54:12.5.2]

802.4.2 Plastic Vent Joints. Plastic pipe and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer’s installation instructions. Plastic pipe venting materials listed and labeled in accordance with UL 1738 shall be installed in accordance with the vent manufacturer’s installation instructions. Where primer is required, it shall be of a contrasting color. [NFPA 54:12.5.3]

802.4.3 Special Gas Vents. Special gas vents shall be listed and labeled in accordance with UL 1738 and installed in accordance with the special gas vent manufacturer’s installation instructions. [NFPA 54:12.5.4]

802.5 Masonry, Metal, and Factory-Built Chimneys. Chimneys shall be installed in accordance with Section 802.5.1 through Section 802.5.3.

802.5.1 Factory-Built Chimneys. Factory-built chimneys shall be installed in accordance with the manufacturer’s installation instructions. Factory-built chimneys used to vent appliances that operate at positive vent pressure shall be listed for such application. [NFPA 54:12.6.1.1]

802.5.1.1 Decorative Shrouds. Decorative shrouds addressed in Section 802.5.4.3 shall be listed or labeled in accordance with UL 103 for factory-built residential chimneys, UL 127 for factory-built fireplaces, or UL 1482 for solid-fuel room heaters.

802.5.1.2 Listing Requirements. Factory-built chimneys shall comply with the requirements of UL 103 or UL 959. Factory-built chimneys for use with wood-burning appliances shall comply with the Type HT requirements of UL 103. [NFPA 211:6.1.3.1, 6.1.3.2]

802.5.2 Metal Chimneys. Metal chimneys shall be built and installed in accordance with NFPA 211. [NFPA 54:12.6.1.2]
**802.5.3 Masonry Chimneys.** Masonry chimneys shall be built and installed in accordance with NFPA 211 and lined with approved one of the following:

1. Approved clay flue lining.
2. A listed chimney lining system, or other listed and labeled in accordance with UL 1777.
3. Other approved material that resists corrosion, erosion, softening, or cracking from vent gases at temperatures not exceeding up to 1800°F (982°C).

**Exception:** Masonry chimney flues lined with a chimney lining system specifically listed for use with listed appliances with draft hoods, Category I appliances, and other appliances listed for use with Type B vents shall be permitted. The liner shall be installed in accordance with the liner manufacturer’s installation instructions. A permanent identifying label shall be attached at the point where the connection is to be made to the liner. The label shall read: “This chimney liner is for appliances that burn gas only. Do not connect to solid- or liquid-fuel-burning appliances or incinerators.” [NFPA 54:12.6.1.3]

**802.5.4 Termination.** A chimney for a residential-type or low-heat appliance shall extend not less than 3 feet (914 mm) above the highest point where it passes through a roof of a building and not less than 2 feet (610 mm) higher than a portion of a building within a horizontal distance of 10 feet (3048 mm). [NFPA 54:12.6.2.1] (See Figure 802.5.4)
802.5.4.1 Medium-Heat Gas Appliances. A chimney for medium-heat appliance shall extend at least less than 10 feet (3048 mm) higher than any portion of any building within 25 feet (7620 mm). [NFPA 54: 12.6.2.2.2]

802.5.4.2 Chimney Height. A chimney shall extend not less than 5 feet (1524 mm) above the highest connected appliance draft hood outlet or flue collar. [NFPA 54: 12.6.2.3]

802.5.4.3 Decorative Shrouds. Decorative shrouds shall not be installed at the termination of factory-built chimneys except where such shrouds are listed and labeled for use with the specific factory-built chimney system and are installed in accordance with the manufacturer’s installation instructions. [NFPA 54: 12.6.2.4]

802.5.5 Size of Chimneys. The effective area of a chimney venting system serving listed appliances with draft hoods, Category I appliances, and other appliances listed for use with Type B vents shall be in accordance with one of the following methods:

(1) Those listed in Section 803.0.

(2) For sizing an individual chimney venting system for a single appliance with a draft hood, the effective areas of the vent connector and chimney flue shall be not less than the area of the appliance flue collar or draft hood outlet or greater than seven times the draft hood outlet area.

(3) For sizing a chimney venting system connected to two appliances with draft hoods, the effective area of the chimney flue shall be not less than the area of the larger draft hood outlet plus 50 percent of the area of the smaller draft hood outlet or greater than seven times the smaller draft hood outlet area.

(4) Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods.

(5) Other approved engineering methods. [NFPA 54: 12.6.3.1]

802.5.6 Inspection of Chimneys or Vents. This inspection shall be made after chimneys, vents, or parts thereof, authorized by the permit, have been installed and before such vent or part thereof has been covered or concealed.

802.5.7 Inspection of Chimneys. Before replacing an existing appliance or connecting a vent connector to a chimney, the chimney passageway shall be examined to ascertain that it is clear and free of obstructions and shall be cleaned where previously used for venting solid- or liquid-fuel-burning appliances or fireplaces. [NFPA 54: 12.6.4.1]

802.5.7.1 Standard. Chimneys shall be lined in accordance with NFPA 211.

Exception: Existing chimneys shall be permitted to have their use continued when an appliance is replaced by an appliance of similar type, input rat-
ing, and efficiency, where the chimney complies with Section 802.5.7 through Section 802.5.7.3 and the sizing of the chimney is in accordance with Section 802.5.5. [NFPA 54:12.6.4.2]

802.5.7.2 Cleanouts. Cleanouts shall be examined to determine that, and where they will not remain tightly closed where, when not in use, they shall be repaired or replaced. [NFPA 54:12.6.4.3]

802.5.7.3 Existing Chimney. Where inspection reveals that an existing chimney is not safe for the intended application, it shall be repaired, rebuilt, lined, relined, or replaced with a vent or chimney in accordance with to conform to NFPA 211, and shall be approved suitable for the appliance to be attached. [NFPA 54:12.6.4.4]

802.5.8 Chimney Serving Appliances Burning Other Fuels. An appliance shall not be connected to a chimney flue serving a separate appliance designed to burn solid fuel. [NFPA 54:12.6.5.1]

802.5.8.1 Gas and Liquid Fuel-Burning Appliances. Where one chimney serves gas appliances and liquid fuel-burning appliances, the appliances shall be connected through separate openings or shall be connected through a single opening where joined by a fitting located as close as practical to the chimney. Where two or more openings are provided into one chimney flue, they shall be at different levels. Where the gas appliance is automatically controlled, it shall be equipped with a safety shutoff device. [NFPA 54:12.6.5.2]

802.5.8.2 Gas and Solid Fuel-Burning Appliances. A listed combination gas- and solid-fuel-burning appliance connected to a single chimney flue shall be equipped with a manual reset device to shut off gas to the main burner in the event of sustained backdraft or flue gas spillage. The chimney flue shall be sized to properly vent the appliance. [NFPA 54:12.6.5.3]

802.5.8.3 Combination Gas- and Oil-Burning Appliances. A single chimney flue serving a listed combination gas- and oil-burning appliance shall be sized to properly vent in accordance with the appliance manufacturer’s instructions. [NFPA 54:12.6.5.4]

802.5.9 Support of Chimneys. All portions of chimneys shall be supported for the weight and design of the materials employed. Listed factory-built chimneys shall be supported and spaced in accordance with the manufacturer’s installation instructions. [NFPA 54:12.6.6]

802.5.10 Cleanouts. Where a chimney that formerly carried flue products from liquid or solid-fuel-burning appliances is used with an appliance using fuel gas, an accessible cleanout shall be provided. The cleanout shall have a tight-fitting cover and be installed so its upper edge is not less than 6 inches (152 mm) below the lower edge of the lowest chimney inlet opening. [NFPA 54:12.6.7]

802.5.11 Space Surrounding Lining or Vent. The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry chimney shall not be used to vent another appliance.

Exception: The insertion of another liner or vent within the chimney as provided in this code and the liner or vent manufacturer’s instructions. [NFPA 54:12.6.8.1]

802.5.11.1 Combustion Air. The remaining space surrounding a chimney liner, gas vent, special gas vent, or plastic piping installed within a masonry, metal or factory-built chimney flue shall not be used to supply combustion air.

Exception: Direct-vent appliances designed for installation in a solid-fuel-burning fireplace where installed in accordance with the manufacturer’s installation instructions. [NFPA 54:12.6.8.2]

802.6 Gas Vents. The installation of gas vents shall meet the following requirements:

1. Gas vents shall be installed in accordance with the manufacturer’s installation instructions.

2. A Type B-W gas vent shall have a listed capacity not less than that of the listed vented wall furnace to which it is connected.

3. Gas vents installed within masonry chimneys shall be installed in accordance with the manufacturer’s installation instructions. Gas vents installed within masonry chimneys shall be identified with a permanent label installed at the point where the vent enters the chimney. The label shall contain the following language: “This gas vent is for appliances that burn gas. Do not connect to solid or liquid fuel-burning appliances or incinerators.”

4. Screws, rivets, and other fasteners shall not penetrate the inner wall of double-wall gas vents, except at the transition from the appliance draft hood outlet, flue collar, or single-wall metal connector to a double-wall vent. [NFPA 54:12.7.4.12.7.2]

802.6.1 Gas Vent Termination Requirements. The termination of gas vents shall terminate in accordance with one of comply with the following requirements:

1. A gas vent shall terminate in accordance with one of the following:

   a) Gas vents that are 12 inches (300 mm) or less in size and located not less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate above the roof in accordance with Figure 802.6.1 and Table 802.6.1.

   b) Gas vents that are over 12 inches (300 mm) in size or are located less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate not less than 2 feet (610 mm) above the highest point where they pass through the roof and not less than 2 feet (610 mm) above a portion of a building within 10 feet (3048 mm) horizontally.
Industrial appliances as provided in Section 802.2.5.

Direct-vent systems as provided in Section 802.2.6.

2. (e) Appliances with integral vents as provided in Section 802.2.7.

3. (f) Mechanical draft systems as provided in Section 802.3.3 through Section 802.3.3.5.

4. (g) Ventilating hoods and exhaust systems as provided in Section 802.3.4 and Section 802.3.4.1.

NFPA 54:12.7.2(1)

802.6.1.1 Type B and L Vents. A Type B or a Type L gas vent shall terminate not less than at least 5 feet (1524 mm) in vertical height above the highest connected appliance draft hood or flue collar. [NFPA 54:12.7.2(2)]

802.6.1.2 Type B-W Vents. A Type B-W gas vent shall terminate not less than at least 12 feet (3658 mm) in vertical height above the bottom of the wall furnace. [NFPA 54:12.7.2(3)]

802.6.1.3 Exterior Wall Termination. A gas vent extending through an exterior wall shall not terminate adjacent to the wall or below eaves or parapets, except as provided in Section 802.2.6 and Section 802.3.3 through Section 802.3.3.5. [NFPA 54:12.7.2(4)]

802.6.1.4 Decorative Shrouds. Decorative shrouds shall not be installed at the termination of gas vents except where such shrouds are listed for use with the specific gas venting system and are installed in accordance with the manufacturer's installation instructions. [NFPA 54:12.7.2(5)]

802.6.1.5 Termination Cap. All gas vents shall extend through the roof flashing, roof jack, or roof thimble and terminate with a listed cap or listed roof assembly. [NFPA 54:12.7.2(6)]

802.6.1.6 Forced Air Inlet. A gas vent shall terminate not less than at least 3 feet (914 mm) above a forced air inlet located within 10 feet (3048 mm). [NFPA 54:12.7.2(7)]

802.6.1.7 Insulation Shield. Where a vent passes through an insulated assembly, an approved metal shield shall be installed between the vent and insulation. The shield shall extend not less than 2 inches (51 mm) above the insulation and be secured to the structure in accordance with the manufacturer's installation instructions.

802.6.2 Size of Gas Vents. Venting systems shall be sized and constructed in accordance with Section 803.0 or other approved engineering methods and the gas vent Section 802.6.2.1 through Section 802.6.2.3 and the appliance manufacturer’s instructions. [NFPA 54:12.7.3.12.7.4]

802.6.2.1 Category I Appliances. The sizing of natural draft venting systems serving one or more listed appliances equipped with a draft hood or appliances listed for use with a Type B gas vent, installed in a single story of a building, shall be in accordance with one of the following:

1. The provisions of Section 803.0.

2. Vents serving fan-assisted combustion system appliances, or combinations of fan-assisted combustion system and draft hood-equipped appliances shall be sized in accordance with Section 803.0 or other approved engineering methods.

TABLE 802.6.1

<table>
<thead>
<tr>
<th>ROOF PITCH</th>
<th>H (minimum) (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat to (\frac{1}{2} )</td>
<td>1.0</td>
</tr>
<tr>
<td>Over (\frac{1}{2}) to (\frac{1}{3} )</td>
<td>1.25</td>
</tr>
<tr>
<td>Over (\frac{1}{3}) to (\frac{1}{4} )</td>
<td>1.5</td>
</tr>
<tr>
<td>Over (\frac{1}{4}) to (\frac{1}{5} )</td>
<td>2.0</td>
</tr>
<tr>
<td>Over (\frac{1}{5}) to (\frac{1}{6} )</td>
<td>2.5</td>
</tr>
<tr>
<td>Over (\frac{1}{6}) to (\frac{1}{12} )</td>
<td>3.25</td>
</tr>
<tr>
<td>Over (\frac{1}{12}) to (\frac{1}{24} )</td>
<td>4.0</td>
</tr>
<tr>
<td>Over (\frac{1}{24}) to (\frac{1}{48} )</td>
<td>5.0</td>
</tr>
<tr>
<td>Over (\frac{1}{48}) to (\frac{1}{96} )</td>
<td>6.0</td>
</tr>
<tr>
<td>Over (\frac{1}{96}) to (\frac{1}{192} )</td>
<td>7.0</td>
</tr>
<tr>
<td>Over (\frac{1}{192}) to (\frac{1}{384} )</td>
<td>7.5</td>
</tr>
<tr>
<td>Over (\frac{1}{384}) to (\frac{1}{768} )</td>
<td>8.0</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm
(3) For sizing an individual gas vent for a single, draft hood-equipped appliance, the effective area of the vent connector and the gas vent shall be not less than the area of the appliance draft hood outlet or exceeding seven times the draft hood outlet area.

(4) For sizing a gas vent connected to two appliances, with draft hoods, the effective area of the vent shall be not less than the area of the larger draft hood outlet plus 50 percent of the area of the smaller draft hood outlet or exceeding seven times the smaller draft hood outlet area.

(5) Approved engineering practices. [NFPA 54:12.7.3.1 12.7.4.1]

802.6.2.2 Vent Offsets. Type B and Type L vents sized in accordance with Section 802.6.2.1(3) or Section 802.6.2.1(4) shall extend in a generally vertical direction with offsets not exceeding 45 degrees except that a vent system having not more than one 60 degree offset shall be permitted. Any angle greater than 45 degrees from the vertical is considered horizontal. The total horizontal distance of a vent plus the horizontal vent connector serving draft hood-equipped appliances shall not be greater than 75 percent of the vertical height of the vent. [NFPA 54:12.7.3.2 12.7.4.2]

802.6.2.3 Category II, Category III, and Category IV Appliances. The sizing of gas vents for Category II, Category III, and Category IV appliances shall be in accordance with the appliance manufacturer’s instructions. The sizing of plastic pipe specified by the appliance manufacturer as a venting material for Category II, Category III, and Category IV appliances shall be in accordance with the appliance manufacturers’ instructions. [NFPA 54:12.7.3.3 12.7.4.3]

802.6.2.4 Sizing. Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods. [NFPA 54:12.7.3.4 12.7.4.4]

802.6.3 Gas Vents Serving Appliances on More than One Floor. A common vent shall be permitted in multistory installations to vent Category I appliances located on more than one floor level, provided the venting system is designed and installed in accordance with approved engineering methods.

For the purpose of this section, crawl spaces, basements, and attics shall be considered as floor levels. [NFPA 54:12.7.4.1 12.7.5.1]

802.6.3.1 Occupiable Space. All appliances connected to the common vent shall be located in rooms separated from an occupiable space. Each of these rooms shall have provisions for an adequate supply of combustion, ventilation, and dilution air that is not supplied from an occupiable space. [NFPA 54:12.7.4.2 12.7.5.2] (See Figure 802.6.3.1)

802.6.3.2 Multistory Venting System. The size of the connectors and common segments of multistory venting systems for appliances listed for use with a Type B double-wall gas vent shall be in accordance with Table 803.2(1), provided all of the following apply:

(1) The available total height (H) for each segment of a multistory venting system is the vertical distance between the level of the highest draft hood outlet or flue collar on that floor and the centerline of the next highest interconnection tee.

(2) The size of the connector for a segment is determined from the appliance’s gas input rate and available connector rise, and shall not be smaller than the draft hood outlet or flue collar size.
(3) The size of the common vertical vent segment, and of the interconnection tee at the base of that segment, is based on the total appliance’s gas input rate entering that segment and its available total height. [NFPA 54:12.7.4.3 12.7.5.3]

802.6.4 Support of Gas Vents. Gas vents shall be supported and spaced in accordance with the manufacturer’s installation instructions. [NFPA 54:12.7.5 12.7.6]

802.6.5 Marking. In those localities where solid and liquid fuels are used extensively, gas vents shall be permanently identified by a label attached to the wall or ceiling at a point where the vent connector enters the gas vent. The label shall read: “This gas vent is for appliances that burn gas. Do not connect to solid or liquid fuel-burning appliances or incinerators.” The Authority Having Jurisdiction shall determine whether its area constitutes such a locality. [NFPA 54:12.7.6 12.7.7]

802.7 Single-Wall Metal Pipe. Single-wall metal pipe shall be constructed of galvanized sheet steel not less than 0.0304 of an inch (0.7722 mm) thick or of other approved, noncombustible, corrosion-resistant material. [NFPA 54:12.8.1]

802.7.1 Cold Climate. Uninsulated single-wall metal pipe shall not be used outdoors for venting appliances in regions where the 99 percent winter design temperature is below 32°F (0°C). [NFPA 54:12.8.2]

802.7.2 Termination. The termination of single-wall metal pipe shall meet the following requirements:

1. Single-wall metal pipe shall terminate at least 5 feet (1524 mm) in vertical height above the highest connected appliance draft hood outlet or flue collar.

2. Single-wall metal pipe shall extend at least 2 feet (610 mm) above the highest point where it passes through a roof of a building and at least 2 feet (610 mm) higher than any portion of a building within a horizontal distance of 10 feet (3048 mm). (See Figure 802.5.4)

3. An approved cap or roof assembly shall be attached to the terminus of a single-wall metal pipe. [NFPA 54:12.8.3]

802.7.3 Installation with Appliances Permitted by Section 802.4. Single-wall metal pipe shall not be used as a vent in dwellings and residential occupancies. [NFPA 54:12.8.4.1]

802.7.3.1 Limitations. Single-wall metal pipe shall be used only for runs directly from the space in which the appliance is located through the roof or exterior wall to the outer air. A pipe passing through a roof shall extend without interruption through the roof flashing, roof jacket, or roof thimble. [NFPA 54:12.8.4.2]

802.7.3.2 Attic or Concealed Space. Single-wall metal pipe shall not originate in any unoccupied attic or concealed space and shall not pass through any attic, inside wall, concealed space, or floor. [NFPA 54:12.8.4.3]

802.7.3.3 Clearances. Minimum clearances from single-wall metal pipe to combustible material shall be in accordance with Table 802.7.3.3. Reduced clearances from single-wall metal pipe to combustible material shall be as specified for vent connectors in Table 303.10.1. [NFPA 54:12.8.4.4]

802.7.3.4 Combustible Exterior Wall. Single-wall metal pipe shall not pass through a combustible exterior wall unless guarded at the point of passage by a ventilated metal thimble not smaller than the following:

1. For listed appliances with draft hoods and appliances listed for use with Type B gas vents, the thimble shall be a minimum of 4 inches (102 mm) larger in diameter than the metal pipe. Where there is a run of not less than 6 feet (1829 mm) of metal pipe in the opening between the draft hood outlet and the thimble, the thimble shall be a minimum of 2 inches (51 mm) larger in diameter than the metal pipe.

<table>
<thead>
<tr>
<th>APPLIANCE</th>
<th>LISTED TYPE B GAS VENT MATERIAL</th>
<th>LISTED TYPE L VENT MATERIAL</th>
<th>SINGLE-WALL METAL PIPE</th>
<th>FACTORY-BUILT CHIMNEY SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed appliance with draft hoods and appliance listed for use with Type B gas vents</td>
<td>As listed</td>
<td>As listed</td>
<td>6</td>
<td>As listed</td>
</tr>
<tr>
<td>Residential boilers and furnaces with listed gas conversion burner and with draft hood</td>
<td>6</td>
<td>6</td>
<td>9</td>
<td>As listed</td>
</tr>
<tr>
<td>Residential appliances listed for use with Type L vents</td>
<td>Not permitted</td>
<td>As listed</td>
<td>9</td>
<td>As listed</td>
</tr>
<tr>
<td>Listed gas-fired toilets</td>
<td>Not permitted</td>
<td>As listed</td>
<td>As listed</td>
<td>As listed</td>
</tr>
<tr>
<td>Unlisted residential appliances with draft hood</td>
<td>Not permitted</td>
<td>6</td>
<td>9</td>
<td>As listed</td>
</tr>
<tr>
<td>Residential and low-heat appliance other than those above</td>
<td>Not permitted</td>
<td>9</td>
<td>18</td>
<td>As listed</td>
</tr>
<tr>
<td>Medium-heat appliance</td>
<td>Not permitted</td>
<td>Not permitted</td>
<td>36</td>
<td>As listed</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

* These clearances shall apply unless the installation instructions of a listed appliance or connector specify different clearances, in which case the listed clearances shall apply.
In accordance with the appliance 802.7.4.3 Venting Capacity.

6
802.7.4 Sizing of Venting System.
802.7.4.1 Sizing of Venting System. A venting system of a single-wall metal pipe shall be sized in accordance with one of the following methods and the appliance manufacturer’s instructions:

(1) For a draft hood-equipped appliance, in accordance with Section 803.0.
(2) For a venting system for a single appliance with a draft hood, the areas of the connector and the pipe each shall not be less than the area of the appliance flue collar or draft hood outlet, whichever is smaller. The vent area shall not exceed ten times the draft hood outlet area.
(3) Other approved engineering methods. [NFPA 54:12.8.5(3)]

802.7.4.2 Non-Round Metal Pipe. Where a single-wall metal pipe is used and has a shape other than round, it shall have an equivalent effective area equal to the effective area of the round pipe for which it is substituted, and the minimum internal dimension of the pipe shall be not less than 2 inches (51 mm). [NFPA 54:12.8.5(2)]

802.7.4.3 Venting Capacity. The vent cap or a roof assembly shall have a venting capacity not less than that of the pipe to which it is attached. [NFPA 54:12.8.5(3)]

802.7.5 Support of Single-Wall Metal Pipe. All portions of single-wall metal pipe shall be supported for the design and weight of the material employed. [NFPA 54:12.8.6]

802.7.6 Marking. Single-wall metal pipe shall comply with the marking provisions of Section 802.6.5. [NFPA 54:12.8.7]

802.8 Through-the-Wall Vent Termination. A mechanical draft venting system shall terminate at least 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm). (See Figure 802.8).

Exceptions:
(1) This provision shall not apply to the combustion-air intake of a direct-vent appliance.
(2) This provision shall not apply to the separation of the integral outdoor-air inlet and flue gas discharge of listed outdoor appliances. [NFPA 54:12.9.1]

802.8.1 Mechanical Draft Venting System. A mechanical draft venting system of other than direct-vent type shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from, or 1 foot (305 mm) above a door, operable window, or gravity air inlet into a building. The bottom of the vent terminal shall be located not less than 12 inches (305 mm) above finished ground level. [NFPA 54:12.9.2]

802.8.2 Direct-Vent Appliance. The vent terminal of a direct-vent appliance with an input of 10 000 Btu/h (3 kW) or less, vent terminals shall be located at least 6 inches (152 mm) from any air opening into a building, an appliance with an input over 10 000 Btu/h (3 kW) but not over 50 000 Btu/h (14.7 kW) shall be installed with a 9 inch (229 mm) vent termination clearance, and an appliance with an input exceeding 50 000 Btu/h (14.7 kW) shall have at least a 12 inch (305 mm) vent termination clearance in accordance with Table 802.8.2. The bottom of the vent terminal and the air intake shall be located at least not less than 12 inches (305 mm) above finished ground level. [NFPA 54:12.9.3]

<table>
<thead>
<tr>
<th>Table 802.8.2 Through-the-Wall Direct Vent Termination Clearances</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>DIRECT VENT APPLIANCE INPUT RATING</th>
<th>THRU THE WALL VENT TERMINAL CLEARANCE FROM ANY AIR OPENING INTO A BUILDING (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 000 Btu/hr and less</td>
<td>6</td>
</tr>
<tr>
<td>Greater than 10 000 Btu/hr and not exceeding 50 000 Btu/hr</td>
<td>225 mm 9</td>
</tr>
<tr>
<td>Greater than 50 000 Btu/hr and not exceeding 150 000 Btu/hr</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 150 000 Btu/hr</td>
<td>In accordance with the appliance manufacturer’s instructions and in no case less than the clearances specified in Section 802.8.1.</td>
</tr>
</tbody>
</table>

For SI Units: 1 inch = 25.4 mm, 1000 British thermal units per hour = 0.293 kW
802.8.3 Category I through Category IV and Non-categorized Appliances. Through-the-wall vents for Category II and Category IV appliances and noncategorized condensing appliances shall not terminate over public walkways or over an area where condensate or vapor could create a nuisance or hazard or could be detrimental to the operation of regulators, relief valves, or other equipment. Where local experience indicates that condensate is a problem with Category I and Category III appliances, this provision shall also apply.

Drains for condensate shall be installed in accordance with the appliance and the vent manufacturer's installation instructions. [NFPA 54:12.9.4]

802.8.4 Annular Spaces. Where vents, including those for direct-vent appliances or combustion air intake pipes, penetrate outside walls of buildings, the annular spaces around such penetrations shall be permanently sealed using approved materials to prevent entry of combustion products into the building. [NFPA 54:12.9.5]

802.8.5 Vent Terminals. Vent systems for Category IV appliances that terminate through an outside wall of a building and discharge flue gases perpendicular to the adjacent wall shall be located not less than 10 feet (3048 mm) horizontally from an operable opening in an adjacent building.

Exception: This shall not apply to vent terminals that are 2 feet (610 mm) or more above or 25 feet (7620 mm) or more below operable openings. [NFPA 54:12.9.6]

802.9 Condensation Drain. Provision shall be made to collect and dispose of condensate from venting systems serving Category II and Category IV appliances and noncategorized condensing appliances in accordance with Section 802.8.3. [NFPA 54:12.10.1]

802.9.1 Local Experience. Where local experience indicates that condensation is a problem, provision shall be made to drain off and dispose of condensate from venting systems serving Category I and Category III appliances in accordance with Section 802.8.3. [NFPA 54:12.10.2]

802.10 Vent Connectors for Category I Appliances. A vent connector shall be used to connect an appliance to a gas vent, chimney, or single-wall metal pipe, except where the gas vent, chimney, or single-wall metal pipe is directly connected to the appliance. [NFPA 54:12.11.1]

802.10.1 Materials. A vent connector shall be made of noncombustible, corrosion resistant material capable of withstanding the vent gas temperature produced by the appliance and of a thickness to withstand physical damage. [NFPA 54:12.11.2.1]

802.10.1.1 Unconditioned Area. Where the vent connector used for an appliance having a draft hood or a Category I appliance is located in or passes through an unconditioned area, attic or crawl space, that portion of the vent connector shall be listed Type B, Type L, or listed vent material having equivalent insulation qualities.
Exception: Single-wall metal pipe located within the exterior walls of the building and located in an unconditioned area other than an attic or a crawl space having a local 99 percent winter design temperature of 5°F (-15°C) or higher. [NFPA 54:12.11.2.2]

802.10.1.2 Residential Type Appliances. Vent connectors for residential-type appliances shall comply with the following:

(1) Vent connectors for listed appliances having draft hoods, appliances having draft hoods and equipped with listed conversion burners, and Category I appliances that are not installed in attics, crawl spaces, or other unconditioned areas shall be one of the following:
   (a) Type B or Type L vent material.
   (b) Galvanized sheet steel not less than 0.018 of an inch (0.457 mm) thick.
   (c) Aluminum (1100 or 3003 alloy or equivalent) sheet not less than 0.027 of an inch (0.686 mm) thick.
   (d) Stainless steel sheet not less than 0.012 of an inch (0.305 mm) thick.
   (e) Smooth interior wall metal pipe having resistance to heat and corrosion equal to or greater than that of Section 802.10.1.2(1)(b), Section 802.10.1.2(1)(c), or Section 802.10.1.2(1)(d).
   (f) A listed vent connector.

(2) Vent connectors shall not be covered with insulation.

Exception: Listed insulated vent connectors shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:12.11.2.3]

802.10.1.3 Non-Residential Low-Heat Appliances. A vent connector for a nonresidential low-heat appliance shall be a factory-built chimney section or steel pipe having resistance to heat and corrosion equal to or greater than that of Section 802.10.1.2(1)(b), Section 802.10.1.2(1)(c), or Section 802.10.1.2(1)(d).

(1) A steel vent connector for an appliance with a vent gas temperature in excess of 1000°F (538°C) measured at the entrance to the connector shall be lined with medium-duty fire brick or the equivalent.

(2) The lining shall be at least 2½ inches (64 mm) thick for a vent connector having a diameter or greatest cross-sectional dimension of 18 inches (457 mm) or less.

(3) The lining shall be at least 4½ inches (114 mm) thick laid on the 4½ inches (114 mm) bed for a vent connector having a diameter or greatest cross-sectional dimension greater than 18 inches (457 mm).

(4) Factory-built chimney sections, if employed, shall be joined together in accordance with the chimney manufacturer’s instructions. [NFPA 54:12.11.2.5]

### TABLE 802.10.1.4
MINIMUM THICKNESS FOR STEEL VENT CONNECTORS FOR MEDIUM-HEAT APPLIANCES

<table>
<thead>
<tr>
<th>VENT CONNECTOR SIZE</th>
<th>DIAMETER (inches)</th>
<th>AREA (square inches)</th>
<th>MINIMUM THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 14</td>
<td>Up to 154</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td>Over 14 to 16</td>
<td>154 to 201</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>Over 16 to 18</td>
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</tr>
<tr>
<td>Over 18</td>
<td>Larger than 254</td>
<td>0.123</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 square inch = 0.000645 m²

802.10.2 Size of Vent Connector. A vent connector for an appliance with a single draft hood or for a Category I fan-assisted combustion system appliance shall be sized and installed in accordance with Section 803.0 or other approved engineering methods. [NFPA 54:12.11.2.5]

802.10.2.1 Manifold. For a single appliance having more than one draft hood outlet or flue collar, the manifold shall be constructed according to the instructions of the appliance manufacturer. Where there are no instructions, the manifold shall be designed and constructed in accordance with approved engineering practices. As an alternative method, the effective area of the manifold shall equal the combined area of the flue collars or draft hood outlets, and the vent connectors shall have a minimum 1 foot (305 mm) rise. [NFPA 54:12.11.2.4]

### TABLE 802.10.1.3
MINIMUM THICKNESS FOR GALVANIZED STEEL VENT CONNECTORS FOR LOW-HEAT APPLIANCES

<table>
<thead>
<tr>
<th>DIAMETER OF CONNECTOR (inches)</th>
<th>MINIMUM THICKNESS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6</td>
<td>0.019</td>
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<tr>
<td>6 to less than 10</td>
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<tr>
<td>10 to 12 inclusive</td>
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<td>Over 16</td>
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</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 square inch = 0.000645 m²
802.10.2.2 Size. Where two or more appliances are connected to a common vent or chimney, each vent connector shall be sized in accordance with Section 803.0 or other approved engineering methods. [NFPA 54:12.11.3.3]

As an alternative method applicable only where all of the appliances are draft hood-equipped, each vent connector shall have an effective area not less than the area of the draft hood outlet of the appliance to which it is connected. [NFPA 54:12.11.3.4]

802.10.2.3 Height. Where two or more appliances are vented through a common vent connector or vent manifold, the common vent connector or vent manifold shall be located at the highest level consistent with available headroom and clearance to combustible material and sized in accordance with Section 803.0 or other approved engineering methods. [NFPA 54:12.11.3.5]

As an alternative method applicable only where there are two draft hood-equipped appliances, the effective area of the common vent connector or vent manifold and all junction fittings shall be not less than the area of the larger vent connector plus 50 percent of the area of the smaller flue collar outlet. [NFPA 54:12.11.3.6]

802.10.2.4 Size Increase. Where the size of a vent connector is increased to overcome installation limitations and obtain connector capacity equal to the appliance input, the size increase shall be made at the appliance draft hood outlet. [NFPA 54:12.11.3.7]

802.10.3 Two or More Appliances Connected to a Single Vent. Where two or more openings are provided into one chimney flue or vent, either of the following shall apply:
(1) The openings shall be at different levels.
(2) The connectors shall be attached to the vertical portion of the chimney or vent at an angle of 45 degrees or less relative to the vertical. [NFPA 54:12.11.4.1]

802.10.3.1 Height of Connector. Where two or more vent connectors enter a common vent, chimney flue, or single-wall metal pipe, the smaller connector shall enter at the highest level consistent with the available headroom or clearance to combustible material. [NFPA 54:12.11.4.2]

802.10.3.2 Pressure. Vent connectors serving Category I appliances shall not be connected to any portion of a mechanical draft system operating under positive static pressure, such as those serving Category III or Category IV appliances. [NFPA 54:12.11.4.3]

802.10.4 Clearance. Minimum clearances from vent connectors to combustible material shall comply with Table 802.7.3.3. Exception: The clearance between a vent connector and combustible material shall be permitted to be reduced where the combustible material is protected as specified for vent connectors in Table 303.10.1. [NFPA 54:12.11.5]

802.10.5 Joints. Joints between sections of connector piping and connections to flue collars or draft hood outlets shall be fastened in accordance with one of the following methods:
(1) Sheet metal screws.
(2) Vent connectors of listed vent material assembled and connected to flue collars or draft hood outlets in accordance with the manufacturer’s instructions.
(3) Other approved means. [NFPA 54:12.11.6]

802.10.6 Slope. A vent connector shall be installed without any dips or sags and shall slope upward toward the vent or chimney at least ¼ inch per foot (20.8 mm/m).
Exception: Vent connectors attached to a mechanical draft system installed in accordance with appliance and the draft system manufacturers’ instructions. [NFPA 54:12.11.7]

802.10.7 Length of Vent Connector. The length of vent connectors shall comply with Section 802.10.7.1 or Section 802.10.7.2.

802.10.7.1 Single Wall Connector. The maximum horizontal length of a single-wall connector shall be 75 percent of the height of the chimney or vent except for engineered systems. [NFPA 54:12.11.8.1]

802.10.7.2 Type B Double Wall Connector. The maximum horizontal length of a Type B double-wall connector shall be 100 percent of the height of the chimney or vent, except for engineered systems. The maximum length of an individual connector for a chimney or vent system serving multiple appliances, from the appliance outlet to the junction with the common vent or another connector, shall be 100 percent of the height of the chimney or vent. [NFPA 54:12.11.8.2]

802.10.8 Support. A vent connector shall be supported for the design and weight of the material employed to maintain clearances and prevent physical damage and separation of joints. [NFPA 54:12.11.9]

802.10.9 Chimney Connection. Where entering a flue in a masonry or metal chimney, the vent connector shall be installed above the extreme bottom to avoid stoppage. Where a thimble or slip joint is used to facilitate removal of the connector, the connector shall be attached to or inserted into the thimble or slip joint to prevent the connector from falling out. Means shall be employed to prevent the connector from entering so far as to restrict the space between its end and the opposite wall of the chimney flue. [NFPA 54:12.11.10]

802.10.10 Inspection. The entire length of a vent connector shall be readily accessible for inspection, cleaning, and replacement. [NFPA 54:12.11.11]

802.10.11 Fireplaces. A vent connector shall not be connected to a chimney flue serving a fireplace unless the fireplace flue opening is permanently sealed. [NFPA 54:12.11.12]
802.10.12 Passage through Ceilings, Floors, or Walls. A vent connector shall not pass through a ceiling, floor, or fire-resistance-rated wall. A single-wall metal pipe connector shall not pass through an interior wall.

Exception: Vent connectors made of listed Type B or Type L vent material and serving listed appliances with draft hoods and other appliances listed for use with Type B gas vents that pass through walls or partitions constructed of combustible material shall be installed with not less than the listed clearance to combustible material.

802.10.12.1 Medium-Heat Appliances. Vent connectors for medium-heat appliances shall not pass through walls or partitions constructed of combustible material. [NFPA 54:12.11.13.2]

802.11 Vent Connectors for Category II, Category III, and Category IV Appliances. The vent connectors for Category II, Category III, and Category IV appliances shall be in accordance with Section 802.4 through Section 802.4.3. [NFPA 54:12.12]

802.12 Draft Hoods and Draft Controls. Vented appliances shall be installed with draft hoods.

Exception: Dual oven-type combination ranges; incinerators; direct-vent appliances; fan-assisted combustion system appliances; appliances requiring chimney draft for operation; single firebox boilers equipped with conversion burners with inputs exceeding 400 000 Btu/h (117 kW); appliances equipped with blast, power, or pressure burners that are not listed for use with draft hoods; and appliances designed for forced venting. [NFPA 54:12.13.1]

802.12.1 Installation. A draft hood supplied with or forming a part of listed vented appliances shall be installed without alteration, exactly as furnished and specified by the appliance manufacturer. [NFPA 54:12.13.2]

Where a draft hood is not supplied by the appliance manufacturer where one is required, a draft hood shall be installed, be of a listed or approved type, and, in the absence of other instructions, be of the same size as the appliance flue collar. Where a draft hood is required with a conversion burner, it shall be of a listed or approved type. [NFPA 54:12.13.2.1]

Where a draft hood of special design is needed or preferable, the installation shall be approved and in accordance with the recommendations of the appliance manufacturer. [NFPA 54:12.13.2.2]

802.12.2 Draft Control Devices. Where a draft control device is part of the appliance or supplied by the appliance manufacturer, it shall be installed in accordance with the manufacturer’s instructions. In the absence of manufacturer’s instructions, the device shall be attached to the flue collar of the appliance or as near to the appliance as practical. [NFPA 54:12.13.3]

802.12.3 Additional Devices. Appliances requiring controlled chimney draft shall be permitted to be equipped with listed double-acting barometric draft regulators installed and adjusted in accordance with the manufacturer’s installation instructions. [NFPA 54:12.13.4]

802.12.4 Location. Draft hoods and barometric draft regulators shall be installed in the same room or enclosure as the appliance in such a manner as to prevent any difference in pressure between the hood or regulator and the combustion air supply. [NFPA 54:12.13.5]

802.12.5 Positioning. Draft hoods and draft regulators shall be installed in the position for which they were designed with reference to the horizontal and vertical planes and shall be located so that the relief opening is not obstructed by any part of the appliance or adjacent construction. The appliance and its draft hood shall be located so that the relief opening is accessible for checking vent operation. [NFPA 54:12.13.6]

802.12.6 Clearance. A draft hood shall be located so that its relief opening is not less than 6 inches (152 mm) from any surface except that of the appliance it serves and the venting system to which the draft hood is connected. Where a greater or lesser clearance is indicated on the appliance label, the clearance shall not be less than that specified on the label. Such clearances shall not be reduced. [NFPA 54:12.13.7]

802.13 Manually Operated Dampers. A manually operated damper shall not be placed in any appliance vent connector. Fixed baffles shall not be classified as manually operated dampers. [NFPA 54:12.14]

802.14 Obstructions. Devices that retard the flow of vent gases shall not be installed in a vent connector, chimney, or vent. The following shall not be considered as obstructions:

(1) Draft regulators and safety controls specifically listed for installation in venting systems and installed in accordance with the manufacturer’s installation instructions.

(2) Approved draft regulators and safety controls designed and installed in accordance with approved engineering methods.

(3) Listed heat reclaimers and automatically operated vent dampers installed in accordance with the manufacturer’s installation instructions.

(4) Vent dampers serving listed appliances installed in accordance with Section 803.1 or Section 803.2 or other approved engineering methods.

(5) Approved economizers, heat reclaimers, and recuperators installed in venting systems of appliances not required to be equipped with draft hoods, provided the appliance manufacturer’s installation instructions cover the installation of such a device in the venting system and performance in accordance with Section 802.3 and Section 802.3.1 is obtained. [NFPA 54:12.16]

802.15 Automatically Operated Vent Dampers. An automatically operated vent damper shall be of a listed type. [NFPA 54:12.15]

802.15.1 Listing. Automatically operated vent dampers for oil-fired appliances shall comply with UL 17. The automatic damper control shall comply with UL 378.
803.0 Sizing of Category I Venting Systems.

803.1 Single Appliance Vent Table 803.1.2(1) through Table 803.1.2(6). Venting Table 803.1.2(1) through Table 803.1.2(6) shall not be used where obstructions are installed in the venting system. The installation of vents serving listed appliances with vent dampers shall be in accordance with the appliance manufacturer’s installation instructions or in accordance with the following:

(1) The maximum capacity of the vent system shall be determined using the “NAT Max” column.

(2) The minimum capacity shall be determined as though the appliance were a fan-assisted appliance, using the “FAN Min” column to determine the minimum capacity of the vent system. Where the corresponding “FAN Min” is “NA”, the vent configuration shall not be permitted and an alternative venting configuration shall be utilized. [NFPA 54:13.1.1]

803.1.1 Vent Downsizing. Where the vent size determined from the tables is smaller than the appliance draft hood outlet or flue collar, the use of the smaller size shall be permitted provided that the installation is in accordance with the following requirements:

(1) The total vent height (H) is not less than 10 feet (3048 mm).

(2) Vents for appliance draft hood outlets or flue collars 12 inches (305 mm) in diameter or smaller are not reduced more than one table size.

(3) Vents for appliance draft hood outlets or flue collars exceeding 12 inches (305 mm) in diameter are not reduced more than two table sizes.

(4) The maximum capacity listed in the tables for a fan-assisted appliance is reduced by 10 percent (0.90 x maximum table capacity).

(5) The draft hood outlet exceeds 4 inches (102 mm) in diameter. A 3 inch (76 mm) diameter vent shall not be connected to a 4 inch (102 mm) diameter draft hood outlet. This provision shall not apply to fan-assisted appliances. [NFPA 54:13.1.2]

803.1.2 Elbows. Single-appliance venting configurations with zero (0) lateral lengths in Table 803.1.2(1), Table 803.1.2(2), and Table 803.1.2(5) shall not have elbows in the venting system. Single-appliance venting with lateral length, include two 90 degree elbows. For each additional elbow up to and including 45 degrees, the maximum capacity listed in the venting tables shall be reduced by 5 percent. For each additional elbow greater than 45 degrees up to and including 90 degrees, the maximum capacity listed in the venting tables shall be reduced by 10 percent. Where multiple offsets occur in a vent, the total lateral length of all offsets combined shall not exceed that specified in Table 803.1.2(1) through Table 803.1.2(5). [NFPA 54:13.1.3]

803.1.3 Zero Lateral. Zero lateral (L) shall apply to a straight vertical vent attached to a top outlet draft hood or flue collar. [NFPA 54:13.1.4]

803.1.4 High-Altitude Installations. Sea level input ratings shall be used where determining maximum capacity for high-altitude installation. Actual input (derated for altitude) shall be used for determining minimum capacity for high-altitude installation. [NFPA 54:13.1.5]

803.1.5 Multiple Input Ratings. For appliances with more than one input rate, the minimum vent capacity (FAN Min) determined from the tables shall be less than the lowest appliance input rating, and the maximum vent capacity (FAN Max/NAT Max) determined from the tables shall exceed the highest appliance rating input. [NFPA 54:13.1.6]

803.1.6 Corrugated Chimney Liner Reduction. Listed corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 803.1.2(1) or Table 803.1.2(2) for Type B vents, with the maximum capacity reduced by 20 percent (0.80 x maximum capacity) and the minimum capacity as shown in Table 803.1.2(1) or Table 803.1.2(2).

Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Section 803.1.2. The 20 percent reduction for corrugated metallic chimney liner systems includes an allowance for one long radius 90 degree (1.57 rad) turn at the bottom of the liner. [NFPA 54:13.1.7]

803.1.7 Connection to Chimney Liners. Connections between chimney liners and listed double-wall connectors shall be made with listed adapters designed for such purpose. [NFPA 54:13.1.8]

803.1.8 Vertical Vent Upsizing Using 7 x Rule. Where the vertical vent has a larger diameter than the vent connector, the vertical vent diameter shall be used to determine the minimum vent capacity, and the connector diameter shall be used to determine the maximum vent capacity. The flow area of the vertical vent shall not exceed seven times the flow area of the listed appliance categorized vent area, flue collar area, or draft hood outlet area unless designed in accordance with approved engineering methods. [NFPA 54:13.1.9]

803.1.9 Draft Hood Conversion Accessories. Draft hood conversion accessories for use with masonry chimneys venting listed Category I fan-assisted appliances shall be listed and installed in accordance with the listed accessory manufacturer’s installation instructions. [NFPA 54:13.1.10]

803.1.10 Chimney and Vent Locations. Table 803.1.2(1) through Table 803.1.2(5) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Table 802.6.1, and where vents terminate in accordance with Section 802.6.1(2), the outdoor portion of the vent shall
be enclosed as required by this paragraph for vents not considered to be exposed to the outdoors, or such venting system shall be engineered. A Type B vent passing through an unventilated enclosure or chase insulated to a value of not less than R8 shall not be considered to be exposed to the outdoors. Table 803.1.2(3) in combination with Table 803.1.2(6) shall be used for clay tile-lined exterior masonry chimneys, provided all of the following requirements are met:

1. The vent connector is Type B double wall.
2. The vent connector length is limited to 18 in./lin. (18 mm/mm) of vent connector diameter.
3. The appliance is draft hood equipped.
4. The input rating is less than the maximum capacity given in Table 803.1.2(3).
5. For a water heater, the outdoor design temperature shall be not less than 5°F (-15°C).
6. For a space-heating appliance, the input rating is greater than the minimum capacity given by Table 803.1.2(6). [NFPA 54:13.1.11]

**803.1.11 Residential and Low-Heat Appliances.**

Flue lining system for residential and low heat appliance shall be in accordance with Section 803.1.11.1 and Section 803.1.11.2.

**803.1.11.1 Clay Flue Lining.** Clay flue lining shall be manufactured in accordance with ASTM C315 or other approved standard.

**803.1.11.2 Chimney Lining.** Chimney lining shall be listed in accordance with UL 1777.

**803.1.12 Corrugated Vent Connector Size.** Corrugated vent connectors shall not be smaller than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter. [NFPA 54:13.1.12]

**803.1.13 Upsizing.** Vent connectors shall not be upsized more than two sizes exceeding the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter. [NFPA 54:13.1.13]

**803.1.14 Single Run of Vent.** In a single run of vent or vent connector, more than one diameter and type shall be permitted to be used, provided that all the sizes and types are permitted by the tables. [NFPA 54:13.1.14]

**803.1.15 Interpolation.** Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. [NFPA 54:13.1.15]

**803.1.16 Extrapolation.** Extrapolation beyond the table entries shall not be permitted. [NFPA 54:13.1.16]

**803.1.17 Engineering Methods.** For vent heights lower than 6 feet (1829 mm) and higher than shown in the tables, engineering methods shall be used to calculate vent capacities. [NFPA 54:13.1.17]

**803.1.18 Height Entries.** Where the actual height of a vent falls between entries in the height column of the applicable table in Table 803.1.2(1) through Table 803.1.2(6), either of the following shall be used:

1. Interpolation.
2. The lower appliance input rating shown in the table entries for FAN MAX and NAT MAX column values, and the higher appliance input rating for the FAN MIN column values. [NFPA 54:13.1.18]

**803.2 Multiple Appliance Vent Table 803.2(1) through Table 803.2(9).** Venting Table 803.2(1) through Table 803.2(9) shall not be used where obstructions are installed in the venting system. The installation of vents serving listed appliances with vent dampers shall be in accordance with the appliance manufacturer’s instructions or in accordance with the following:

1. The maximum capacity of the vent connector shall be determined using the NAT Max column.
2. The maximum capacity of the vertical vent or chimney shall be determined using the FAN + NAT column when the second appliance is a fan-assisted appliance, or the NAT + NAT column when the second appliance is equipped with a draft hood.
3. The minimum capacity shall be determined as if the appliance were a fan-assisted appliance, as follows:
   a. The minimum capacity of the vent connector shall be determined using the FAN Min column.
   b. The FAN + FAN column shall be used when the second appliance is a fan-assisted appliance, and the FAN + NAT column shall be used when the second appliance is equipped with a draft hood, to determine whether the vertical vent or chimney configuration is not permitted (NA). Where the vent configuration is NA, the vent configuration shall not be permitted and an alternative venting configuration shall be utilized. [NFPA 54:13.2.1]

**803.2.1 Vent Connector Maximum Length.** The maximum vent connector horizontal length shall be 18 inches per inch (18 mm/mm) of connector diameter as shown in Table 803.2.1, or as permitted by Section 803.2.2. [NFPA 54:13.2.2]

**803.2.2 Vent Connector Exceeding Maximum Length.** The vent connector shall be routed to the vent utilizing the shortest possible route. Connectors with longer horizontal lengths than those listed in Table 803.2.1 are permitted under the following conditions:

1. The maximum capacity (FAN Max or NAT Max) of the vent connector shall be reduced 10 percent for each additional multiple of the length listed in Table 803.2.1. For example, the maximum length listed for a 4 inch (100 mm) connector is 6 feet (1829 mm). With a connector length greater than 6 feet (1829 mm) but not exceeding 12 feet (3658 mm), the maximum capacity must be reduced by 10 percent (0.90 x maximum vent connector capacity). With a connector length greater than 12 feet (3658 mm) but not exceeding 18 feet (5486 mm), the maximum capacity must be reduced by 20 percent (0.80 x maximum vent capacity).
(2) For a connector serving a fan-assisted appliance, the minimum capacity (FAN Min) of the connector shall be determined by referring to the corresponding single appliance table. For Type B double-wall connectors, Table 803.1.2(1) shall be used. For single-wall connectors, Table 803.1.2(2) shall be used. The height (H) and lateral (L) shall be measured according to the procedures for a single-appliance vent, as if the other appliances were not present. [NFPA 54:13.2.3]

<table>
<thead>
<tr>
<th>TABLE 803.2.1</th>
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<tr>
<td>VENT CONNECTOR MAXIMUM LENGTH</td>
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<table>
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<tr>
<th>CONNECTOR DIAMETER (inches)</th>
<th>MAXIMUM CONNECTOR HORIZONTAL LENGTH (feet)</th>
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</table>

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

803.2.3 Vent Connector Manifolds. Where the vent connectors are combined prior to entering the vertical portion of the common vent to form a common vent manifold, the size of the common vent manifold and the common vent shall be determined by applying a 10 percent reduction (0.90 x maximum common vent capacity) to the common vent capacity part of the common vent tables. The length of the common vent manifold (LM) shall not exceed 18 inches per inch (18 mm/mm) of common vent diameter (D). [See Figure 802.6.3.2] [NFPA 54:13.2.4] (See Figure 802.6.3.2)

803.2.4 Vent Offsets. Where the common vertical vent is offset, the maximum capacity of the common vent shall be reduced in accordance with Section 803.2.5, and the horizontal length of the common vent offset shall not exceed 18 inches per inch (18 mm/mm) of common vent diameter (D). Where multiple offsets occur in a common vent, the total horizontal length of offsets combined shall not exceed 18 inches per inch (18 mm/mm) of the common vent diameter. [NFPA 54:13.2.5]

803.2.5 Elbows Reduction in Vents. For each elbow up to and including 45 degrees (0.79 rad) in the common vent, the maximum common vent capacity listed in the venting tables shall be reduced by 5 percent. For each elbow exceeding 45 degrees (0.79 rad) up to and including 90 degrees (1.57 rad), the maximum common vent capacity listed in the venting tables shall be reduced by 10 percent. [NFPA 54:13.2.6]

803.2.6 Elbows in Connectors. The vent connector capacities listed in the common vent sizing tables include allowance for two 90 degree elbows. For each additional elbow up to and including 45 degrees, the maximum vent connector capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 45 degrees up to and including 90 degrees, the maximum vent connector capacity listed in the venting tables shall be reduced by 10 percent. [NFPA 54:13.2.7]

803.2.7 Common Vent Minimum Size. The cross-sectional area of the common vent shall be equal to or greater than the cross-sectional area of the largest connector. [NFPA 54:13.2.8]

803.2.8 Tee and Wye Fittings. Tee and wye fittings connected to a common gas vent shall be considered as part of the common gas vent and constructed of materials consistent with that of the common gas vent. [NFPA 54:13.2.9]

803.2.9 Size of Fittings. At the point where tee or wye fittings connect to a common gas vent, the opening size of the fitting shall be equal to the size of the common vent. Such fittings shall not be prohibited from having reduced size openings at the point of connection of appliance gas vent connectors. [NFPA 54:13.2.10]

803.2.10 High-Altitude Installations. Sea level input ratings shall be used where when determining maximum capacity for high-altitude installation. Actual input (derated for altitude) shall be used for determining minimum capacity for high-altitude installation. [NFPA 54:13.2.11]

803.2.11 Connector Rise. The connector rise (R) for each appliance connector shall be measured from the draft hood outlet or flue collar to the centerline where the vent gas streams come together. [NFPA 54:13.2.12]

803.2.12 Vent Height. For multiple appliances all located on one floor, the available total height (H) shall be measured from the highest draft hood outlet or flue collar up to the level of the outlet of the common vent. [NFPA 54:13.2.13]

803.2.13 Multistory Installations. For multistory installations, the available total height (H) for each segment of the system shall be the vertical distance between the highest draft hood outlet or flue collar entering that segment and the centerline of the next higher interconnection tee. [See Figure 803.2.13] [NFPA 54:13.2.14] (See Figure 803.2.13)
803.2.14 Size of Vents for Multistory Installations. The size of the lowest connector and of the vertical vent leading to the lowest interconnection of a multistory system shall be in accordance with Table 803.1.2(1) or Table 803.1.2(2) for available total height \(H\) up to the lowest interconnection. (See Figure 803.2.13) [NFPA 54:13.2.15]

803.2.15 Vent Type Multistory Installation. Where used in multistory systems, vertical common vents shall be Type B double-wall and shall be installed with a listed vent cap. [NFPA 54:13.2.16]

803.2.16 Offsets in Multistory Installations. Offsets in multistory common vent systems shall be limited to a single offset in each system, and systems with an offset shall comply with the following:

1. The offset angle shall not exceed 45 degrees (0.79 rad) from vertical.
2. The horizontal length of the offset shall not exceed 18 inches per inch (18 mm/mm) of common vent diameter of the segment in which the offset is located.
3. For the segment of the common vertical vent containing the offset, the common vent capacity listed in the common venting tables shall be reduced by 20 percent (0.80 x maximum common vent capacity).
4. A multistory common vent shall not be reduced in size above the offset. [NFPA 54:13.2.17]

803.2.17 Vertical Vent Size Limitation. Where two or more appliances are connected to a vertical vent or chimney, the flow area of the largest section of vertical vent or chimney shall not exceed seven times the smallest listed appliance categorized vent areas, flue collar area, or draft hood outlet area unless designed in accordance with approved engineering methods. [NFPA 54:13.2.18]
803.2.18 Multiple Input Ratings. For appliances with more than one input rate, the minimum vent connector capacity (FAN Min) determined from the tables shall be less than the lowest appliance input rating, and the maximum vent connector capacity (FAN Max or NAT Max) determined from the tables shall exceed be greater than the highest appliance input rating. [NFPA 54:13.2.19]

803.2.19 Corrugated Metallic Chimney Liner Reduction. Listed corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 803.2(1) or Table 803.2(2) for Type B vents, with the maximum capacity reduced by 20 percent (0.80 x maximum capacity) and the minimum capacity as shown in Table 803.2(1) or Table 803.2(2). Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Section 803.2.5 and Section 803.2.6. The 20 percent reduction for corrugated metallic chimney liner systems includes an allowance for one long radius 90 degree (1.57 rad) turn at the bottom of the liner. [NFPA 54:13.2.20]

803.2.20 Chimneys and Vents. Table 803.2(1) through Table 803.2(5) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. A Type B vent passing through an unventilated enclosure or chase insulated to a value of not less than R8 shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Table 802.6.1, and where vents terminate in accordance with Section 802.6.1(1), the outdoor portion of the vent shall be enclosed as required by this section for vents not considered to be exposed to the outdoors or such venting system shall be engineered. Table 803.2(6) through Table 803.2(9) shall be used for clay-tile-lined exterior masonry chimneys, provided all the following conditions are met:

(1) The vent connector is Type B double-wall.
(2) At least one appliance is draft hood-equipped.
(3) The combined appliance input rating is less than the maximum capacity given by Table 803.2(6) (for NAT+NAT) or Table 803.2(8) (for FAN+NAT).
(4) The input rating of each space-heating appliance is greater than the minimum input rating given by Table 803.2(7) (for NAT+NAT) or Table 803.2(9) (for FAN+NAT).
(5) The vent connector sizing is in accordance with Table 803.2(3). [NFPA 54:13.2.22]

803.2.21 Vent Connector Sizing. Vent connectors shall not be increased more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter. Vent connectors for draft hood-equipped appliances shall not be smaller than the draft hood outlet diameter. Where a vent connector size(s) determined from the tables for a fan-assisted appliance(s) is smaller than the flue collar diameter, the use of the smaller size(s) shall be permitted, provided that the installation complies with all of the following conditions:

(1) Vent connectors for fan-assisted appliance flue collars 12 inches (300 mm) in diameter or smaller are not reduced by more than one table size [e.g., 12 inches to 10 inches (300 mm to 250 mm) is a one-size reduction] and those larger than 12 inches (300 mm) in diameter are not reduced more than two table sizes [e.g., 24 inches to 20 inches (600 mm to 500 mm) is a two-size reduction].
(2) The fan-assisted appliance(s) is common vented with a draft hood-equipped appliance(s).
(3) The vent connector has a smooth interior wall. [NFPA 54:13.2.24]

803.2.22 Combination of Pipe Types and Sizes. All combinations of pipe sizes, single-wall metal pipe, and double-wall metal pipe shall be allowed within any connector run(s) or within the common vent, provided ALL of the appropriate tables permit ALL of the desired sizes and types of pipe, as if they were used for the entire length of the subject connector or vent. Where single-wall and Type B double-wall metal pipes are used for vent connectors within the same venting system, the common vent shall be sized using Table 803.2(2) or Table 803.2(4) as appropriate. [NFPA 54:13.2.25]

803.2.23 Multiple Connector and Vent Sizes. Where a table permits more than one diameter of pipe to be used for a connector or vent, all the permitted sizes shall be permitted to be used. [NFPA 54:13.2.26]

803.2.24 Interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. [NFPA 54:13.2.27]

803.2.25 Extrapolation. Extrapolation beyond the table entries shall not be permitted. [NFPA 54:13.2.28]

803.2.26 Engineering Methods. For vent heights lower than 6 feet (1829 mm) and higher than shown in the tables, engineering methods shall be used to calculate vent capacities. [NFPA 54:13.2.29]

803.2.27 Height Entries. Where the actual height of a vent falls between entries in the height column of the applicable table in Table 803.2(1) through Table 803.2(9), one of the following shall be used:

(1) Interpolation.
(2) The lower appliance input rating shown in the table entries for FAN MAX and NAT MAX column values; and the higher appliance input rating for the FAN MIN column values. [NFPA 54:13.2.30]
99% Winter Design Temperatures for the Contiguous United States

This map is a necessarily generalized guide to temperatures in the contiguous United States. Temperatures shown for areas such as mountainous regions and large urban centers may not be accurate. The climate data used to develop this map are from the 1993 ASHRAE Handbook – Fundamentals (Chapter 24, Table 1: Climate Conditions for the United States).

For 99% winter design temperatures in Alaska, consult the ASHRAE Handbook — Fundamentals.

99% winter design temperatures for Hawaii are greater than 37°F

For SI units: °C = (°F-32)/1.8

FIGURE 803.1.2(6)
RANGE OF WINTER DESIGN TEMPERATURES USED IN ANALYZING EXTERIOR MASONRY CHIMNEYS IN THE UNITED STATES
[NFPA 54: FIGURE F.2.4]
## TABLE 803.1.2(1)
TYPE B DOUBLE-WALL GAS VENT (NFPA 54: TABLE 13.1(a))

<table>
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<th>NUMBER OF APPLIANCES:</th>
<th>SINGLE</th>
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<tr>
<td>APPLIANCE TYPE:</td>
<td>CATEGORY I</td>
</tr>
<tr>
<td>APPLIANCE VENT CONNECTION:</td>
<td>CONNECTED DIRECTLY TO VENT</td>
</tr>
</tbody>
</table>

### VENT DIAMETER – D (inch)

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<tr>
<th>HEIGHT H (feet)</th>
<th>LATERAL L (feet)</th>
<th>FAN</th>
<th>NAT</th>
<th>FAN</th>
<th>NAT</th>
<th>FAN</th>
<th>NAT</th>
<th>FAN</th>
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</tr>
</tbody>
</table>

### APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
CHIMNEYS AND VENTS

TABLE 803.1.2(1)
TYPE B DOUBLE-WALL GAS VENT [NFPA 54: TABLE 13.1(a)] (continued)
NUMBER OF APPLIANCES: SINGLE
APPLIANCE TYPE: CATEGORY I
APPLIANCE VENT CONNECTION: CONNECTED DIRECTLY TO VENT
VENT DIAMETER – D (inch)
8

9

10

12

14

APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR
FAN

NAT

FAN

NAT

FAN

NAT

FAN

NAT

FAN

NAT

LATERAL
L
(feet)

Min

Max

Max

Min

Max

Max

Min

Max

Max

Min

Max

Max

Min

Max

Max

6

0
2
4
6

0
53
79
93

698
425
419
413

370
285
279
273

0
63
93
110

897
543
536
530

470
370
362
354

0
75
110
128

1121
675
668
661

570
455
445
435

0
103
147
171

1645
982
975
967

850
650
640
630

0
138
191
219

2267
1346
1338
1330

1170
890
880
870

8

0
2
5
8

0
50
83
99

780
483
473
463

415
322
313
303

0
60
99
117

1006
619
607
596

537
418
407
396

0
71
115
137

1261
770
758
746

660
515
503
490

0
98
154
180

1858
1124
1110
1097

970
745
733
720

0
130
199
231

2571
1543
1528
1514

1320
1020
1010
1000

10

0
2
5
10

0
48
81
104

847
533
522
504

450
355
346
330

0
57
95
122

1096
684
671
651

585
457
446
427

0
68
112
142

1377
852
839
817

720
560
547
525

0
93
149
187

2036
1244
1229
1204

1060
850
829
795

0
124
192
238

2825
1713
1696
1669

1450
1130
1105
1080

15

0
2
5
10
15

0
45
76
99
115

970
633
620
600
580

525
414
403
386
373

0
53
90
116
134

1263
815
800
777
755

682
544
529
507
491

0
63
105
135
155

1596
1019
1003
977
953

840
675
660
635
610

0
86
140
177
202

2380
1495
1476
1446
1418

1240
985
967
936
905

0
114
182
227
257

3323
2062
2041
2009
1976

1720
1350
1327
1289
1250

20

0
2
5
10
15
20
0
2
5
10
15
20
30

0
41
73
95
111
125
0
33
69
91
105
119
149

1057
711
697
675
654
634
1173
826
811
788
765
743
702

575
470
460
443
427
410
650
535
524
507
490
473
444

0
50
86
112
129
145
0
42
82
107
124
139
171

1384
917
902
877
853
830
1548
1072
1055
1028
1002
977
929

752
612
599
576
557
537
855
700
688
668
648
628
594

0
59
101
130
150
167
0
54
96
125
143
160
195

1756
1150
1133
1105
1078
1052
1977
1351
1332
1301
1272
1243
1189

930
755
738
710
688
665
1060
865
851
829
807
784
745

0
81
135
172
195
217
0
74
127
164
187
207
246

2637
1694
1674
1641
1609
1578
3004
2004
1981
1944
1908
1873
1807

1350
1100
1079
1045
1018
990
1550
1310
1289
1254
1220
1185
1130

0
107
174
220
248
273
0
98
164
209
237
260
305

3701
2343
2320
2282
2245
2210
4252
2786
2759
2716
2674
2633
2555

1900
1520
1498
1460
1425
1390
2170
1800
1775
1733
1692
1650
1585

IN

R

PR
EP

30

T

HEIGHT
H
(feet)

50

0
2
5
10
15
20
30

0
26
65
86
100
113
141

1297
975
960
935
911
888
844

708
615
605
589
572
556
522

0
33
77
101
117
131
161

1730
1276
1259
1230
1203
1176
1125

952
813
798
773
747
722
670

0
41
90
118
136
151
183

2231
1620
1600
1567
1536
1505
1446

1195
1010
996
972
948
924
876

0
66
118
154
177
195
232

3441
2431
2406
2366
2327
2288
2214

1825
1513
1495
1466
1437
1408
1349

0
86
151
196
222
244
287

4934
3409
3380
3332
3285
3239
3150

2550
2125
2102
2064
2026
1987
1910

100

0
2
5
10
15
20
30
50

0
21
60
80
93
105
131
197

1411
1155
1141
1118
1095
1073
1029
944

770
700
692
679
666
653
627
575

0
25
71
94
109
122
149
217

1908
1536
1519
1492
1465
1438
1387
1288

1040
935
926
910
895
880
849
787

0
30
82
108
126
141
170
241

2491
1975
1955
1923
1892
1861
1802
1688

1310
1170
1159
1142
1124
1107
1071
1000

0
44
107
142
163
181
215
292

3925
3027
3002
2961
2920
2880
2803
2657

2050
1820
1803
1775
1747
1719
1663
1550

0
72
136
180
206
226
265
350

5729
4313
4282
4231
4182
4133
4037
3856

2950
2550
2531
2500
2469
2438
2375
2250

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m2

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111


### CHIMNEYS AND VENTS

**TABLE 803.1.2(1)**

**TYPE B DOUBLE-WALL GAS VENT [NFPA 54: TABLE 13.1(a)] (continued)**

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<thead>
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<th>HEIGHT H (feet)</th>
<th>LATERAL L (feet)</th>
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<th>NAT</th>
<th>FAN</th>
<th>NAT</th>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

**NUMBER OF APPLIANCES:**

**ALGORITHM TYPE:**

**APPLIANCE VENT CONNECTION:**

**CONNECTED DIRECTLY TO VENT**

**VENT DIAMETER – D (inch)**

**APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR**

**PREPRINT**

**UNIFORM MECHANICAL CODE - PREPRINT**

112
### TABLE 803.1.2(2)
**TYPE B DOUBLE-WALL GAS VENT [NFPA 54: TABLE 13.1(b)]**

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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
| HEIGHT \( H \) (feet) | LATERAL \( L \) (feet) | NUMBER OF APPLIANCES: SINGLE | APPLIANCE TYPE: CATEGORY I | APPLIANCE VENT CONNECTION: SINGLE-WALL METAL CONNECTOR | VENT DIAMETER \(- D \) (inch) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|------------------|------------------|---------------------------------|---------------------------------|-------------------------------------------------|------------------|------|-----|------|-----|------|-----|------|-----|------|-----|-----|
|                  |                  |                                 |                                 |                                                 | 8                | 9    | 10  | 12   |     |     |     |     |     |     |     |     |     |     |     |
| 6                | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 8                | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 10               | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 15               | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 20               | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 30               | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 50               | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
| 100              | 0                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 2                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 4                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |
|                  | 6                |                                 |                                 |                                                 |                 |      |     |      |     |      |     |      |     |      |     |      |

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.1.2(3)
**MASONRY CHIMNEY [NFPA 54: TABLE 13.1(c)]**

| Minimum internal area of chimney (square inches) | 12 | 19 | 28 | 38 | 50 |
| Maximum internal area of chimney (square inches) | 7 times the listed appliance categorized vent area, flue collar area, or draft hood outlet areas. |

<table>
<thead>
<tr>
<th>HEIGHT ( H ) (feet)</th>
<th>LATERAL ( L ) (feet)</th>
<th>APPLIANCE TYPE</th>
<th>APPLIANCE VENT CONNECTION</th>
<th>TYPE B DOUBLE-WALL CONNECTOR DIAMETER – ( D ) (inch)</th>
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<tbody>
<tr>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
CHIMNEYS AND VENTS

<table>
<thead>
<tr>
<th>TABLE 803.1.2(3)</th>
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</thead>
<tbody>
<tr>
<td>MASONRY CHIMNEY [NFPA 54: TABLE 13.1(c)] (continued)*</td>
</tr>
</tbody>
</table>

| HEIGHT $H$ (feet) | LATERAL $L$ (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|-------------------|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                   |                   | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 6                 | 2                 | NA  | NA  | 247 | NA  | NA  | 320 | NA  | NA  | 401 | NA  | 581 |
| 5                 | NA                | NA  | 231 | NA  | NA  | 298 | NA  | NA  | 376 | NA  | 561 |
| 8                 | 2                 | NA  | NA  | 266 | 84  | 590 | 350 | 100 | 728 | 446 | 139 | 1024 | 651 |
| 5                 | NA                | NA  | 247 | NA  | NA  | 328 | 149 | 711 | 423 | 201 | 1007 | 640 |
| 8                 | NA                | NA  | 239 | NA  | NA  | 318 | 173 | 695 | 410 | 231 | 990  | 623 |
| 10                | 2                 | 68  | 519 | 298 | 82  | 655 | 388 | 98  | 810 | 491 | 136 | 1144 | 724 |
| 5                 | NA                | NA  | 277 | 124 | 638 | 365 | 146 | 791 | 466 | 196 | 1124 | 712 |
| 10                | NA                | NA  | 263 | 155 | 610 | 347 | 182 | 762 | 444 | 240 | 1093 | 668 |
| 15                | 2                 | 64  | 613 | 336 | 77  | 779 | 441 | 92  | 968 | 562 | 127 | 1376 | 841 |
| 5                 | 99                | 594 | 313 | 118 | 759 | 416 | 139 | 946 | 533 | 186 | 1352 | 828 |
| 10                | 126               | 565 | 296 | 148 | 727 | 394 | 173 | 912 | 567 | 229 | 1315 | 777 |
| 15                | NA                | NA  | 281 | 171 | 698 | 375 | 198 | 880 | 485 | 259 | 1280 | 742 |
| 20                | 2                 | 61  | 678 | 375 | 73  | 867 | 491 | 87  | 1083| 627 | 121 | 1548 | 953 |
| 5                 | 95                | 658 | 350 | 113 | 845 | 463 | 133 | 1059| 597 | 179 | 1523 | 933 |
| 10                | 122               | 627 | 332 | 143 | 811 | 440 | 167 | 1022| 566 | 221 | 1482 | 879 |
| 15                | NA                | NA  | 314 | 165 | 780 | 418 | 191 | 987 | 541 | 251 | 1443 | 840 |
| 20                | NA                | NA  | 296 | 186 | 750 | 397 | 214 | 955 | 513 | 277 | 1406 | 807 |
| 30                | 2                 | 57  | 762 | 421 | 68  | 985 | 558 | 81  | 1240| 717 | 111 | 1793 | 1112|
| 5                 | 90                | 741 | 393 | 106 | 962 | 526 | 125 | 1216| 683 | 169 | 1766 | 1094|
| 10                | 115               | 709 | 373 | 135 | 927 | 500 | 158 | 1176| 648 | 210 | 1721 | 1025|
| 15                | NA                | NA  | 353 | 156 | 893 | 476 | 181 | 1139| 621 | 239 | 1679 | 981 |
| 20                | NA                | NA  | 332 | 176 | 860 | 450 | 203 | 1103| 592 | 264 | 1638 | 940 |
| 30                | NA                | NA  | 288 | 186 | 750 | 397 | 214 | 955 | 513 | 277 | 1406 | 807 |
| 50                | 2                 | 51  | 840 | 477 | 61  | 1106| 633 | 72  | 1413| 812 | 99  | 2080 | 1243|
| 5                 | 83                | 819 | 445 | 98  | 1083| 596 | 116 | 1387| 774 | 155 | 2052 | 1225|
| 10                | NA                | NA  | 424 | 126 | 1047| 567 | 147 | 1347| 733 | 195 | 2006 | 1147|
| 15                | NA                | NA  | 400 | 146 | 1010| 539 | 170 | 1307| 702 | 222 | 1961 | 1099|
| 20                | NA                | NA  | 376 | 165 | 977 | 511 | 190 | 1269| 669 | 246 | 1916 | 1050|
| 30                | NA                | NA  | 327 | 186 | 946 | 548 | 233 | 1196| 623 | 295 | 1832 | 984 |

Minimum internal area of chimney (square inches) | 63 |
Maximum internal area of chimney (square inches) | 78 |

Seven times the listed appliance categorized vent area, flue collar area, or draft hood outlet areas.

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.1.2(4)
MASONRY CHIMNEY [NFPA 54: TABLE 13.1(d)]

| HEIGHT H (feet) | LATERAL L (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|-----------------|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                 |                 | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 6               | 2               | NA  | NA  | 28  | NA  | NA  | 52  | NA  | NA  | 86  | NA  | NA  | 130 | NA  | 180 |
|                 | 5               | NA  | NA  | 25  | NA  | NA  | 48  | NA  | NA  | 81  | NA  | NA  | 116 | NA  | 164 |
| 8               | 2               | NA  | NA  | 29  | NA  | NA  | 55  | NA  | NA  | 93  | NA  | NA  | 145 | NA  | 197 |
|                 | 5               | NA  | NA  | 26  | NA  | NA  | 51  | NA  | NA  | 87  | NA  | NA  | 133 | NA  | 182 |
|                 | 8               | NA  | NA  | 23  | NA  | NA  | 47  | NA  | NA  | 82  | NA  | NA  | 126 | NA  | 174 |
| 10              | 2               | NA  | NA  | 31  | NA  | NA  | 61  | NA  | NA  | 102 | NA  | NA  | 161 | NA  | 220 |
|                 | 5               | NA  | NA  | 28  | NA  | NA  | 56  | NA  | NA  | 95  | NA  | NA  | 147 | NA  | 203 |
|                 | 10              | NA  | NA  | 24  | NA  | NA  | 49  | NA  | NA  | 86  | NA  | NA  | 137 | NA  | 189 |
| 15              | 2               | NA  | NA  | 35  | NA  | NA  | 67  | NA  | NA  | 113 | NA  | NA  | 178 | 166 | 473 | 249 |
|                 | 5               | NA  | NA  | 32  | NA  | NA  | 61  | NA  | NA  | 106 | NA  | NA  | 163 | NA  | 230 |
|                 | 10              | NA  | NA  | 27  | NA  | NA  | 54  | NA  | NA  | 96  | NA  | NA  | 151 | NA  | 214 |
|                 | 15              | NA  | NA  | 24  | NA  | NA  | 46  | NA  | NA  | 87  | NA  | NA  | 138 | NA  | 198 |
| 20              | 2               | NA  | NA  | 38  | NA  | NA  | 73  | NA  | NA  | 123 | NA  | NA  | 200 | 163 | 520 | 273 |
|                 | 5               | NA  | NA  | 35  | NA  | NA  | 67  | NA  | NA  | 115 | NA  | NA  | 183 | NA  | 252 |
|                 | 10              | NA  | NA  | 32  | NA  | NA  | 61  | NA  | NA  | 106 | NA  | NA  | 183 | NA  | 252 |
|                 | 15              | NA  | NA  | 27  | NA  | NA  | 54  | NA  | NA  | 96  | NA  | NA  | 156 | NA  | 217 |
|                 | 20              | NA  | NA  | 24  | NA  | NA  | 46  | NA  | NA  | 87  | NA  | NA  | 138 | NA  | 198 |
| 30              | 2               | NA  | NA  | 41  | NA  | NA  | 81  | NA  | NA  | 136 | NA  | NA  | 215 | 158 | 578 | 302 |
|                 | 5               | NA  | NA  | 38  | NA  | NA  | 75  | NA  | NA  | 127 | NA  | NA  | 196 | NA  | 279 |
|                 | 10              | NA  | NA  | 35  | NA  | NA  | 66  | NA  | NA  | 113 | NA  | NA  | 182 | NA  | 260 |
|                 | 15              | NA  | NA  | 32  | NA  | NA  | 61  | NA  | NA  | 106 | NA  | NA  | 183 | NA  | 252 |
|                 | 20              | NA  | NA  | 27  | NA  | NA  | 54  | NA  | NA  | 96  | NA  | NA  | 156 | NA  | 217 |
|                 | 30              | NA  | NA  | 24  | NA  | NA  | 46  | NA  | NA  | 87  | NA  | NA  | 138 | NA  | 198 |
| 50              | 2               | NA  | NA  | 41  | NA  | NA  | 91  | NA  | NA  | 160 | NA  | NA  | 250 | NA  | 350 |
|                 | 5               | NA  | NA  | 38  | NA  | NA  | 81  | NA  | NA  | 136 | NA  | NA  | 249 | NA  | 321 |
|                 | 10              | NA  | NA  | 35  | NA  | NA  | 66  | NA  | NA  | 113 | NA  | NA  | 236 | NA  | 301 |
|                 | 15              | NA  | NA  | 32  | NA  | NA  | 61  | NA  | NA  | 106 | NA  | NA  | 226 | NA  | 278 |
|                 | 20              | NA  | NA  | 27  | NA  | NA  | 54  | NA  | NA  | 96  | NA  | NA  | 180 | NA  | 258 |
|                 | 30              | NA  | NA  | 24  | NA  | NA  | 46  | NA  | NA  | 87  | NA  | NA  | 182 | NA  | 182 |

**Minimum internal area of chimney (square inches)**

Minimum internal area of chimney (square inches) for the listed appliance categorized vent area, flue collar area, or draft hood outlet areas.

**Maximum internal area of chimney (square inches)**

Seven times the listed appliance categorized vent area, flue collar area, or draft hood outlet areas.

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable
### CHIMNEYS AND VENTS

#### TABLE 803.1.2(4)

**MASONRY CHIMNEY [NFPA 54: TABLE 13.1(d)] (continued)**

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<td>APPLIANCE TYPE: CATEGORY I</td>
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**SINGLE-WALL METAL CONNECTOR DIAMETER – D (inch)**

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**TO BE USED WITH CHIMNEY AREAS WITHIN THE SIZE LIMITS AT BOTTOM**

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<th>APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR</th>
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**Minimum internal area of chimney (square inches)**: 63

**Maximum internal area of chimney (square inches)**: 78

Seven times the listed appliance categorized vent area, flue collar area, or draft hood outlet areas.

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.1.2(5)
SINGLE-WALL METAL PIPE OR TYPE B ASBESTOS-CEMENT VENT [NFPA 54: TABLE 13.1(e)]

**NUMBER OF APPLIANCES:** SINGLE  
**APPLIANCE TYPE:** DRAFT HOOD-EQUIPPED  
**APPLIANCE VENT CONNECTION:** CONNECTED DIRECTLY TO PIPE OR VENT

<table>
<thead>
<tr>
<th>HEIGHT (H) (feet)</th>
<th>LATERCAL (L) (feet)</th>
<th>MAXIMUM APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>10</th>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
# Table 803.1.2(6)

## Exterior Masonry Chimney [NFPA 54: Table 13.1(f)]

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<th>VENT HEIGHT</th>
<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
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<td>H (feet)</td>
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<td>NA</td>
</tr>
<tr>
<td>30</td>
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<tr>
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</table>

Local 99% winter design temperature: 37°F or greater

<table>
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<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
</tr>
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<td>H (feet)</td>
<td>6</td>
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<tr>
<td>30</td>
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<td>50</td>
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</table>

Local 99% winter design temperature: 27°F to 36°F

<table>
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<td>H (feet)</td>
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<tr>
<td>8</td>
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Local 99% winter design temperature: 17°F to 26°F

<table>
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<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
</tr>
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<td>H (feet)</td>
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<tr>
<td>8</td>
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<td>30</td>
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Local 99% winter design temperature: 5°F to 16°F

<table>
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</tr>
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<td>H (feet)</td>
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</tr>
<tr>
<td>6</td>
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<tr>
<td>8</td>
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</table>

Local 99% winter design temperature: -10°F to 4°F

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<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
</tr>
</thead>
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<td>30</td>
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</table>

Local 99% winter design temperature: -11°F or lower

Not recommended for any vent configurations

---

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m², °C = (°F-32)/1.8

**Notes:**

1 See Figure 803.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2 NA: Not applicable.
### TABLE 803.2(1)
**TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(a)]**

| VENT HEIGHT (feet) | CONNECTOR RISE (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|--------------------|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 6                  | 1                     | 22  | 37  | 26  | 35  | 66  | 46  | 46  | 106 | 72  | 58  | 164 | 104 |
|                    | 2                     | 23  | 41  | 31  | 37  | 75  | 55  | 48  | 121 | 86  | 60  | 183 | 124 |
|                    | 3                     | 24  | 44  | 35  | 38  | 81  | 62  | 49  | 132 | 96  | 62  | 199 | 139 |
| 8                  | 1                     | 22  | 40  | 27  | 35  | 72  | 48  | 49  | 114 | 76  | 64  | 176 | 109 |
|                    | 2                     | 23  | 44  | 32  | 36  | 80  | 57  | 51  | 128 | 90  | 66  | 195 | 129 |
|                    | 3                     | 24  | 47  | 36  | 37  | 87  | 64  | 53  | 139 | 101 | 67  | 210 | 145 |
| 10                 | 1                     | 22  | 43  | 28  | 34  | 78  | 50  | 49  | 123 | 78  | 65  | 189 | 113 |
|                    | 2                     | 23  | 47  | 33  | 36  | 86  | 59  | 51  | 136 | 93  | 67  | 206 | 134 |
|                    | 3                     | 24  | 50  | 37  | 37  | 92  | 67  | 52  | 146 | 104 | 69  | 220 | 150 |
| 15                 | 1                     | 21  | 50  | 30  | 33  | 89  | 53  | 47  | 142 | 83  | 64  | 220 | 120 |
|                    | 2                     | 22  | 53  | 35  | 35  | 96  | 63  | 49  | 153 | 99  | 66  | 235 | 142 |
|                    | 3                     | 24  | 55  | 40  | 36  | 102 | 71  | 51  | 163 | 111 | 68  | 248 | 160 |
| 20                 | 1                     | 21  | 54  | 31  | 33  | 99  | 56  | 46  | 157 | 87  | 62  | 246 | 125 |
|                    | 2                     | 22  | 57  | 30  | 34  | 105 | 66  | 48  | 167 | 104 | 64  | 259 | 149 |
|                    | 3                     | 23  | 60  | 42  | 35  | 110 | 74  | 50  | 176 | 116 | 66  | 271 | 168 |
| 30                 | 1                     | 20  | 62  | 33  | 34  | 113 | 59  | 45  | 181 | 93  | 60  | 288 | 134 |
|                    | 2                     | 21  | 64  | 33  | 33  | 118 | 70  | 47  | 190 | 110 | 62  | 299 | 158 |
|                    | 3                     | 22  | 66  | 44  | 34  | 123 | 79  | 48  | 198 | 124 | 64  | 309 | 178 |
| 50                 | 1                     | 19  | 71  | 36  | 30  | 133 | 64  | 43  | 216 | 101 | 57  | 349 | 145 |
|                    | 2                     | 21  | 73  | 43  | 32  | 137 | 76  | 45  | 223 | 119 | 59  | 358 | 172 |
|                    | 3                     | 22  | 75  | 48  | 33  | 141 | 86  | 46  | 229 | 134 | 61  | 366 | 194 |
| 100                | 1                     | 18  | 82  | 37  | 28  | 158 | 66  | 40  | 262 | 104 | 53  | 442 | 150 |
|                    | 2                     | 19  | 83  | 44  | 30  | 161 | 79  | 42  | 267 | 123 | 55  | 447 | 178 |
|                    | 3                     | 20  | 84  | 50  | 31  | 163 | 89  | 44  | 272 | 138 | 57  | 452 | 200 |

### COMMON VENT CAPACITY

| VENT HEIGHT (feet) | FAN +FAN | FAN +NAT | NAT +FAN | NAT +NAT | FAN +FAN | FAN +NAT | NAT +FAN | NAT +NAT | FAN +FAN | FAN +NAT | NAT +FAN | NAT +NAT |
|--------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 6                  | 92       | 81       | 65       | 140      | 116      | 103      | 204      | 161      | 147      | 309      | 248      | 200      |
| 8                  | 101      | 90       | 73       | 155      | 129      | 114      | 224      | 178      | 163      | 339      | 275      | 223      |
| 10                 | 110      | 97       | 79       | 169      | 141      | 124      | 243      | 194      | 178      | 367      | 299      | 242      |
| 15                 | 125      | 112      | 91       | 195      | 164      | 144      | 283      | 228      | 206      | 427      | 352      | 280      |
| 20                 | 136      | 123      | 102      | 215      | 183      | 160      | 314      | 255      | 229      | 475      | 394      | 310      |
| 30                 | 152      | 138      | 118      | 244      | 210      | 185      | 361      | 297      | 266      | 547      | 459      | 360      |
| 50                 | 167      | 153      | 134      | 279      | 244      | 214      | 421      | 353      | 310      | 641      | 547      | 423      |
| 100                | 175      | 163      | NA       | 311      | 277      | NA       | 489      | 421      | NA       | 751      | 658      | 479      |

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
**TABLE 803.2(1)**  
**TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(a)] (continued)**

| VENT HEIGHT H (feet) | CONNECTOR RISE R (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|---------------------|-------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                     |                         | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 6                   | 1                       | 92  | 296 | 185 |     | 109 | 376 | 237 |     | 128 | 466 | 289 |
|                     | 2                       | 95  | 333 | 220 |     | 112 | 424 | 282 |     | 131 | 526 | 345 |
|                     | 3                       | 97  | 363 | 248 |     | 114 | 463 | 317 |     | 134 | 575 | 386 |
| 8                   | 1                       | 100 | 320 | 194 |     | 118 | 408 | 248 |     | 138 | 507 | 303 |
|                     | 2                       | 103 | 356 | 230 |     | 121 | 454 | 294 |     | 141 | 564 | 358 |
|                     | 3                       | 105 | 384 | 258 |     | 123 | 492 | 330 |     | 143 | 612 | 402 |
| 10                  | 1                       | 106 | 341 | 200 |     | 125 | 436 | 257 |     | 146 | 542 | 314 |
|                     | 2                       | 109 | 374 | 238 |     | 128 | 479 | 305 |     | 149 | 596 | 372 |
|                     | 3                       | 111 | 402 | 268 |     | 131 | 515 | 342 |     | 152 | 642 | 417 |
| 15                  | 1                       | 110 | 389 | 214 |     | 134 | 493 | 273 |     | 162 | 609 | 333 |
|                     | 2                       | 112 | 419 | 253 |     | 137 | 532 | 323 |     | 165 | 658 | 394 |
|                     | 3                       | 115 | 445 | 286 |     | 140 | 565 | 365 |     | 167 | 700 | 444 |
| 20                  | 1                       | 107 | 436 | 224 |     | 131 | 552 | 285 |     | 158 | 681 | 347 |
|                     | 2                       | 110 | 463 | 265 |     | 134 | 587 | 339 |     | 161 | 725 | 414 |
|                     | 3                       | 113 | 486 | 300 |     | 137 | 618 | 383 |     | 164 | 764 | 466 |
| 30                  | 1                       | 103 | 512 | 238 |     | 125 | 649 | 305 |     | 151 | 802 | 372 |
|                     | 2                       | 105 | 535 | 282 |     | 129 | 679 | 360 |     | 155 | 840 | 439 |
|                     | 3                       | 108 | 555 | 317 |     | 132 | 706 | 405 |     | 158 | 874 | 494 |
| 50                  | 1                       | 97  | 627 | 257 |     | 120 | 797 | 330 |     | 144 | 964 | 403 |
|                     | 2                       | 100 | 645 | 306 |     | 123 | 820 | 392 |     | 148 | 1014 | 478 |
|                     | 3                       | 103 | 661 | 343 |     | 126 | 842 | 441 |     | 151 | 1043 | 538 |
| 100                 | 1                       | 91  | 810 | 266 |     | 112 | 1038 | 341 |     | 135 | 1285 | 417 |
|                     | 2                       | 94  | 822 | 316 |     | 115 | 1054 | 405 |     | 139 | 1306 | 494 |
|                     | 3                       | 97  | 834 | 355 |     | 118 | 1069 | 455 |     | 142 | 1327 | 555 |

**COMMON VENT CAPACITY**

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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²
### TABLE 803.2(1)
TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(a)] (continued)*

| VENT HEIGHT (feet) | CONNECTOR RISE R (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|--------------------|-------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                    |                         | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 12                 |                         |     |     |     |     |     |     |     |     |     |     |     |
| 14                 |                         |     |     |     |     |     |     |     |     |     |     |     |
| 16                 |                         |     |     |     |     |     |     |     |     |     |     |     |
| 18                 |                         |     |     |     |     |     |     |     |     |     |     |     |

**APPLIANCE VENT CONNECTION:** TYPE B DOUBLE-WALL CONNECTOR

**VENT CONNECTOR DIAMETER – D (inch)**

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**APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU PER HOUR**

**APPLIANCE TYPE:** Category I

**NUMBER OF APPLIANCES:** Two or More

**COMMON VENT CAPACITY**

**TYPE B DOUBLE-WALL COMMON VENT DIAMETER – D (inch)**

**COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR**

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### CHIMNEYS AND VENTS

**TABLE 803.2(1)**

**TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(a)]** (continued)*

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**COMMON VENT CAPACITY**

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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.2(2)
**TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(b)]**

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**NUMBER OF APPLIANCES:**
- TWO OR MORE
- CATEGORY I
- SINGLE-WALL METAL CONNECTOR

**VENT CONNECTOR CAPACITY**

**SINGLE-WALL METAL VENT CONNECTOR DIAMETER – D (inch)**

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**COMMON VENT CAPACITY**

**TYPE B DOUBLE-WALL COMMON VENT DIAMETER – D (inch)**

| VENT HEIGHT H (feet) | FAN +FAN | FAN +NAT | NAT +NAT | FAN +FAN | FAN +NAT | NAT +NAT | FAN +FAN | FAN +NAT | NAT +NAT | FAN +FAN | FAN +NAT | NAT +NAT | FAN +FAN | FAN +NAT | NAT +NAT |
|----------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 6                    | NA       | 78       | 64       | NA       | 113      | 99       | 200      | 154      | 144      | 304      | 244      | 196      | 269      | 218      | 304      | 218      |
| 8                    | NA       | 87       | 71       | NA       | 126      | 111      | 218      | 173      | 159      | 331      | 292      | 236      | 343      | 274      | 343      | 274      |
| 10                   | NA       | 94       | 76       | 163      | 137      | 120      | 237      | 189      | 174      | 357      | 292      | 236      | 343      | 274      | 343      | 274      |
| 15                   | 121      | 108      | 88       | 189      | 159      | 140      | 275      | 221      | 200      | 416      | 343      | 274      | 343      | 274      | 343      | 274      |
| 20                   | 131      | 118      | 98       | 208      | 177      | 156      | 305      | 247      | 223      | 463      | 383      | 302      | 446      | 349      | 446      | 349      |
| 30                   | 145      | 132      | 113      | 236      | 202      | 180      | 350      | 286      | 257      | 533      | 446      | 349      | 529      | 410      | 529      | 410      |
| 50                   | 159      | 145      | 128      | 268      | 233      | 208      | 406      | 337      | 296      | 622      | 529      | 410      | 633      | 464      | 633      | 464      |
| 100                  | 166      | 153      | NA       | 297      | 263      | NA       | 469      | 398      | NA       | 726      | 633      | 464      | 529      | 410      | 633      | 464      |

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.*
### Table 803.2(2)  
**Type B Double-Wall Vent [NFPA 54: Table 13.2(b)] (continued)**

| VENT HEIGHT $H$ (feet) | CONNECTOR RISE $R$ (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|------------------------|---------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                        |                           | Min | Max | Max |     | Min | Max |     | Min | Max |     | Max |
|                        | 8                          |     |     |     |     |     |     |     |     |     |     |     |
|                        | 9                          |     |     |     |     |     |     |     |     |     |     |     |
|                        | 10                         |     |     |     |     |     |     |     |     |     |     |     |
| 6                      | 1                          | 262 | 293 | 183 | 325 | 373 | 234 | 447 | 463 | 286 |     |     |
|                        | 2                          | 271 | 331 | 219 | 334 | 422 | 281 | 458 | 524 | 344 |     |     |
|                        | 3                          | 279 | 361 | 247 | 344 | 462 | 316 | 468 | 574 | 385 |     |     |
| 8                      | 1                          | 285 | 316 | 191 | 352 | 403 | 244 | 481 | 502 | 299 |     |     |
|                        | 2                          | 293 | 353 | 228 | 360 | 450 | 292 | 492 | 560 | 355 |     |     |
|                        | 3                          | 302 | 381 | 256 | 370 | 489 | 328 | 501 | 609 | 400 |     |     |
| 10                     | 1                          | 302 | 335 | 196 | 372 | 429 | 252 | 506 | 534 | 308 |     |     |
|                        | 2                          | 311 | 369 | 235 | 381 | 473 | 302 | 517 | 589 | 368 |     |     |
|                        | 3                          | 320 | 398 | 265 | 391 | 511 | 339 | 528 | 637 | 413 |     |     |
| 15                     | 1                          | 312 | 380 | 208 | 397 | 482 | 266 | 556 | 596 | 324 |     |     |
|                        | 2                          | 321 | 411 | 248 | 407 | 522 | 317 | 568 | 646 | 387 |     |     |
|                        | 3                          | 331 | 438 | 281 | 418 | 557 | 360 | 579 | 690 | 437 |     |     |
| 20                     | 1                          | 306 | 425 | 217 | 390 | 538 | 276 | 546 | 664 | 336 |     |     |
|                        | 2                          | 317 | 453 | 259 | 400 | 574 | 331 | 558 | 709 | 403 |     |     |
|                        | 3                          | 326 | 476 | 294 | 412 | 607 | 375 | 570 | 750 | 457 |     |     |
| 30                     | 1                          | 296 | 497 | 230 | 378 | 630 | 294 | 528 | 779 | 358 |     |     |
|                        | 2                          | 307 | 521 | 274 | 389 | 662 | 349 | 541 | 819 | 425 |     |     |
|                        | 3                          | 316 | 542 | 309 | 400 | 690 | 394 | 555 | 855 | 482 |     |     |
| 50                     | 1                          | 284 | 604 | 245 | 364 | 768 | 314 | 507 | 951 | 384 |     |     |
|                        | 2                          | 294 | 623 | 293 | 376 | 793 | 375 | 520 | 983 | 458 |     |     |
|                        | 3                          | 304 | 640 | 331 | 387 | 816 | 423 | 535 | 1013 | 518 |     |     |
| 100                    | 1                          | 269 | 774 | 249 | 345 | 993 | 321 | 476 | 1236 | 393 |     |     |
|                        | 2                          | 279 | 788 | 299 | 358 | 1011 | 383 | 490 | 1259 | 469 |     |     |
|                        | 3                          | 289 | 801 | 339 | 368 | 1027 | 431 | 506 | 1280 | 527 |     |     |

### Common Vent Capacity

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<th>FAN +NAT</th>
<th>NAT +NAT</th>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²
### TABLE 803.2(3)
MASONRY CHIMNEY [NFPA 54: TABLE 13.2(c)]*

| VENT HEIGHT (feet) | CONNECTOR RISE (feet) | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT | FAN | NAT |
|--------------------|-----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                    |                       | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| 6                  | 1                     | 24  | 33  | 21  | 39  | 62  | 40  | 52  | 106 | 67  | 194 | 101 | 87  | 274 |
|                    | 2                     | 26  | 43  | 28  | 41  | 79  | 52  | 53  | 133 | 85  | 230 | 124 | 89  | 324 |
|                    | 3                     | 27  | 49  | 34  | 42  | 92  | 61  | 55  | 155 | 97  | 262 | 143 | 91  | 369 |
| 8                  | 1                     | 24  | 39  | 22  | 39  | 72  | 41  | 55  | 117 | 69  | 213 | 105 | 94  | 304 |
|                    | 2                     | 26  | 47  | 29  | 40  | 87  | 53  | 57  | 140 | 86  | 246 | 127 | 97  | 350 |
|                    | 3                     | 27  | 52  | 34  | 42  | 97  | 62  | 59  | 159 | 98  | 269 | 145 | 99  | 383 |
| 10                 | 1                     | 24  | 42  | 22  | 38  | 80  | 42  | 55  | 130 | 71  | 232 | 108 | 101 | 324 |
|                    | 2                     | 26  | 50  | 29  | 40  | 93  | 54  | 57  | 153 | 87  | 261 | 129 | 103 | 366 |
|                    | 3                     | 27  | 55  | 35  | 41  | 105 | 63  | 58  | 170 | 100 | 284 | 148 | 106 | 397 |
| 15                 | 1                     | 24  | 48  | 23  | 38  | 93  | 44  | 54  | 154 | 74  | 277 | 114 | 100 | 384 |
|                    | 2                     | 25  | 55  | 31  | 39  | 105 | 55  | 56  | 174 | 89  | 299 | 134 | 103 | 419 |
|                    | 3                     | 26  | 59  | 35  | 41  | 115 | 64  | 57  | 189 | 102 | 319 | 153 | 105 | 448 |
| 20                 | 1                     | 24  | 52  | 24  | 37  | 102 | 46  | 53  | 172 | 77  | 313 | 119 | 98  | 437 |
|                    | 2                     | 25  | 58  | 31  | 39  | 114 | 56  | 55  | 190 | 91  | 335 | 138 | 101 | 467 |
|                    | 3                     | 26  | 63  | 35  | 40  | 123 | 65  | 57  | 204 | 104 | 353 | 157 | 104 | 493 |
| 30                 | 1                     | 24  | 84  | 25  | 37  | 111 | 48  | 52  | 192 | 82  | 357 | 127 | 96  | 504 |
|                    | 2                     | 25  | 60  | 32  | 38  | 122 | 58  | 54  | 208 | 95  | 376 | 145 | 99  | 531 |
|                    | 3                     | 26  | 64  | 36  | 40  | 131 | 66  | 56  | 221 | 107 | 392 | 163 | 103 | 554 |
| 50                 | 1                     | 24  | 81  | 25  | 36  | 116 | 51  | 51  | 209 | 89  | 405 | 143 | 92  | 582 |
|                    | 2                     | 24  | 59  | 32  | 37  | 127 | 61  | 53  | 225 | 102 | 421 | 161 | 95  | 604 |
|                    | 3                     | 26  | 64  | 36  | 39  | 135 | 69  | 55  | 237 | 115 | 435 | 180 | 98  | 624 |
| 100                | 1                     | 23  | 46  | 24  | 38  | 108 | 50  | 49  | 208 | 92  | 428 | 155 | 88  | 640 |
|                    | 2                     | 24  | 53  | 31  | 37  | 120 | 60  | 51  | 224 | 105 | 444 | 174 | 92  | 660 |
|                    | 3                     | 25  | 59  | 35  | 38  | 130 | 68  | 53  | 237 | 118 | 458 | 193 | 94  | 679 |

### COMMON VENT CAPACITY

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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.2(3)

**MASONRY CHIMNEY** [NFPA 54: TABLE 13.2(c)] (continued)

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#### COMMON VENT CAPACITY

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<th>NAT +FAN</th>
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**For SI units:** 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.2(4)
MASONRY CHIMNEY [NFPA 54: TABLE 13.2(d)]

<table>
<thead>
<tr>
<th>VENT HEIGHT H (feet)</th>
<th>SINGLE-WALL METAL VENT CONNECTOR DIAMETER – D (inch)</th>
<th>COMMON VENT CAPACITY</th>
<th>MINIMUM INTERNAL AREA OF MASONRY CHIMNEY FLUE (square inches)</th>
<th>COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR</th>
<th>NUMBER OF APPLIANCES:</th>
<th>APPLIANCE TYPE:</th>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### CHIMNEYS AND VENTS

**TABLE 803.2(4)**

**MASONRY CHIMNEY [NFPA 54: TABLE 13.2(d)] (continued)**

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### COMMON VENT CAPACITY

**MINIMUM INTERNAL AREA OF MASONRY CHIMNEY FLUE (square inches)**

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<th>NAT +NAT</th>
<th>FAN +FAN</th>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.2(5)
SINGLE-WALL METAL PIPE OR TYPE B ASBESTOS-CEMENT VENT [NFPA 54: TABLE 13.2(e)]*

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<td>APPLIANCE TYPE:</td>
<td>DRAFT HOOD-EQUIPMENT</td>
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<td>APPLIANCE VENT CONNECTION:</td>
<td>DIRECT TO PIPE OR VENT</td>
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#### VENT CONNECTOR CAPACITY

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#### COMMON VENT CAPACITY

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<th>7</th>
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</table>

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.

### TABLE 803.2(6)
EXTERIOR MASONRY CHIMNEY [NFPA 54: TABLE 13.2(f)]*

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<td>APPLIANCE VENT CONNECTION:</td>
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#### COMBINED APPLIANCE MAXIMUM INPUT RATING IN THOUSANDS OF BTU PER HOUR

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<th>12</th>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
TABLE 803.2(7)
EXTERIOR MASONRY CHIMNEY (NFPA 54: TABLE 13.2(g))

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Local 99% winter design temperature: 37°F or greater

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Local 99% winter design temperature: 27°F to 36°F

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Local 99% winter design temperature: 17°F to 26°F

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Local 99% winter design temperature: 5°F to 16°F

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Local 99% winter design temperature: 4°F or lower

Not recommended for any vent configurations

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m², °C = (°F-32)/1.8

Notes:
1 See Figure 803.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2 NA: Not applicable.
TABLE 803.2(8)
EXTERIOR MASONRY CHIMNEY [NFPA 54: TABLE 13.2(h)]

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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²
* NA: Not applicable.
## CHIMNEYS AND VENTS

### TABLE 803.2(9)
**EXTERIOR MASONRY CHIMNEY [NFPA 54: TABLE 13.2(i)]**\(^1,2\)

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<td>NA</td>
<td>NA</td>
<td>603</td>
<td>667</td>
<td>805</td>
</tr>
<tr>
<td>50</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>955</td>
<td>1003</td>
</tr>
<tr>
<td>100</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Local 99% winter design temperature: -11°F or lower</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not recommended for any vent configurations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m², °C = (°F-32)/1.8

Notes:

1. See Figure 803.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2. NA: Not applicable.
CHAPTER 9
INSTALLATION OF SPECIFIC APPLIANCES

901.0 General.
901.1 Applicability. This chapter addresses requirements for the design, construction, and installation of specific appliances. In addition to the requirements of this chapter, appliances shall comply with the general requirements of Chapter 3.

902.0 General.
902.1 Nonindustrial Appliance. This chapter is applicable primarily to nonindustrial-type appliances and installations and, unless specifically indicated, does not apply to industrial-type appliances and installations. Listed appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions or, as elsewhere specified in this chapter, as applicable to the appliance. Unlisted appliances shall be installed as specified in this part as applicable to the appliances. For additional information concerning particular appliances and accessories, including industrial types, reference can be made to the standards listed in Chapter 17.

902.2 Combustion Air from Bedroom or Bathroom. Appliances shall not be installed so their combustion, ventilation, and dilution air are obtained only from a bedroom or bathroom unless the bedroom or bathroom has the required volume in accordance with Section 701.4. [NFPA 54:10.1.2]

902.3 Added or Converted Appliances. When additional or replacement appliances or equipment is installed or an appliance is converted to gas from another fuel, the location in which the appliances or equipment is to be operated shall be checked to verify the following:
(1) Air for combustion and ventilation is provided where required, in accordance with the provisions of Section 701.0. Where existing facilities are not adequate, they shall be upgraded to meet Section 701.0 specifications.
(2) The installation components and appliances meet the clearances to combustible material provisions of Section 303.10. It shall be determined that the installation and operation of the additional or replacement appliances do not render the remaining appliances unsafe for continued operation.
(3) The venting system is constructed and sized in accordance with the provisions of Section 802.0. Where the existing venting system is not adequate, it shall be upgraded to comply with Section 802.0. [NFPA 54:9.1.2]

902.4 Type of Gas(es). The appliance shall be connected to the fuel gas for which it was designed. No attempt shall be made to convert the appliance from the gas specified on the rating plate for use with a different gas without consulting the manufacturer’s installation instructions, the serving gas supplier, or the appliance manufacturer for complete instructions. [NFPA 54:9.1.3]

902.5 Safety Shutoff Devices for Unlisted LP-Gas Appliances Used Indoors. Unlisted appliances for use with undiluted LP-Gases and installed indoors, except attended laboratory equipment, shall be equipped with safety shutoff devices of the complete shutoff type. [NFPA 54:9.1.4]

902.6 Fuel Input Rate. The fuel input rate to the appliance shall not be increased or decreased in violation of the approved rating at the altitude where it is being used.

902.7 Use of Air or Oxygen Under Pressure. Where air or oxygen under pressure is used in connection with the gas supply, effective means such as a back pressure regulator and relief valve shall be provided to prevent air or oxygen from passing back into the gas piping. Where oxygen is used, installation shall be in accordance with NFPA 51. [NFPA 54:9.1.5]

902.8 Building Structural Members. Appliances and equipment shall be furnished either with load-distributing bases or with a sufficient number of supports to prevent damage to either the building structure or the appliance and the equipment. [NFPA 54:9.1.8.1]

902.8.1 Structural Capacity. At the locations selected for installation of appliances and equipment, the dynamic and static load-carrying capacities of the building structure shall be checked to determine whether they are adequate to carry the additional loads. The appliances and equipment shall be supported and shall be connected to the piping so as not to exert undue stress on the connections. [NFPA 54:9.1.8.2]

902.9 Flammable Vapors. Appliances shall not be installed in areas where the open use, handling, or dispensing of flammable liquids occurs, unless the design, operation, or installation reduces the potential of ignition of the flammable vapors. Appliances installed in compliance with Section 305.1 through Section 305.1.2, Section 303.11, or Section 303.12 shall be considered to comply with the intent of this provision. [NFPA 54:9.1.9]

902.10 Solid-Fuel Burning Appliances. Unless otherwise specified, solid-fuel burning appliances shall be installed in accordance with NFPA 211 and the manufacturer’s installation instructions.

902.11 Combination of Appliances and Equipment. Any combination of appliances, equipment, attachments, or devices used together shall be in accordance with the standards that apply to the individual appliance and equipment. [NFPA 54:9.1.21]

902.12 Protection of Gas Appliances from Fumes or Gases Other than Products of Combustion. Non-direct-vent appliances installed in beauty shops, barber shops, or other facilities where chemicals that generate corrosive or flammable products such as aerosol sprays are routinely used shall be located in a mechanical room separate or partitioned off from other areas with provisions for combustion and dilution air from outdoors. Direct-vent appliances in such facilities shall be in accordance with the appliance manufacturer’s installation instructions. [NFPA 54:9.1.6.2]

902.13 Process Air. In addition to air needed for combustion in commercial or industrial processes, process air shall be
provided as required for cooling of appliances, equipment, or material; for controlling dew point, heating, drying, oxidation, dilution, safety exhaust, odor control, and air for compressors; and for comfort and proper working conditions for personnel. [NFPA 54:9.1.7]

902.14 Gas Appliance Pressure Regulators. Where the gas supply pressure is higher than that at which the appliance is designed to operate or varies beyond the design pressure limits of the appliance, a gas appliance pressure regulator shall be installed. [NFPA 54:9.1.1.18]

902.15 Venting of Gas Appliance Pressure Regulators. Venting of gas appliance pressure regulators shall comply with the following requirements:

1. Appliance pressure regulators requiring access to the atmosphere for successful operation shall be equipped with vent piping leading outdoors or, if the regulator vent is an integral part of the appliance, into the combustion chamber adjacent to a continuous pilot, unless constructed or equipped with a vent limiting means to limit the escape of gas from the vent opening in the event of diaphragm failure.

2. Vent limiting means shall be employed on listed appliance pressure regulators only.

3. In the case of vents leading outdoors, means shall be employed to prevent water from entering this piping and also to prevent blockage of vents by insects and foreign matter.

4. Under no circumstances shall a regulator be vented to the appliance flue or exhaust system.

5. In the case of vents entering the combustion chamber, the vent shall be located so the escaping gas is readily ignited by the pilot and the heat liberated thereby does not adversely affect the normal operation of the safety shutoff system. The terminus of the bleed line shall be securely held in a fixed position relative to the pilot. For manufactured gas, the need for a flame arrester in the bleed line piping shall be determined.

6. A bleed line(s) from an appliance pressure regulator and a bleed line(s) from a diaphragm-type valve shall not be connected to a common manifold terminating in a combustion chamber. Vent lines shall not terminate in positive-pressure-type combustion chambers. [NFPA 54:9.1.20]

903.0 Air-Conditioning Appliances.

903.1 Electric Air Conditioners. Electric air conditioning systems designed for permanent installation shall comply with UL 1995 or UL 60335-2-40.

903.2 Gas-Fired Air Conditioners and Heat Pumps. Gas-fired air conditioning shall comply with Section 903.2.1 through Section 903.2.7.

903.2.1 Independent Gas Piping. Gas piping serving heating appliances shall be permitted to also serve cooling appliances where heating and cooling appliances cannot be operated simultaneously. [NFPA 54:10.2.1]

903.2.2 Connection of Gas Engine-Powered Air Conditioners. To protect against the effects of normal vibration in service, gas engines shall not be rigidly connected to the gas supply piping. [NFPA 54:10.2.2]

903.2.3 Clearances for Indoor Installation. The installation of air-conditioning appliances shall comply with the following requirements:

1. Listed air-conditioning appliances shall be installed with clearances in accordance with the terms of their listing and the manufacturer’s installation instructions.

2. Unlisted air-conditioning appliances shall be installed with clearances from combustible material of not less than 18 inches (457 mm) above the appliance and at the sides, front, and rear and in accordance with the manufacturer’s installation instructions. [NFPA 54:10.2.3(2)]

3. Listed and unlisted air-conditioning appliances shall be permitted to be installed with reduced clearances to combustible material, provided that the combustible material or appliance is protected as described in Table 303.10.1 and such reduction is allowed by the manufacturer’s installation instructions. [NFPA 54:10.2.3(3)]

4. Where the furnace plenum is adjacent to plaster on metal lath or noncombustible material attached to combustible material, the clearance shall be measured to the surface of the plaster or other noncombustible finish where the clearance specified is 2 inches (51 mm) or less. [NFPA 54:10.2.3(4)]

5. Listed air-conditioning appliances shall have the clearance from supply ducts, within 3 feet (914 mm) of the furnace plenum be not less than that specified from the furnace plenum. No clearance is necessary beyond this distance. [NFPA 54:10.2.3(5)]
903.2.4 Assembly and Installation. Air-conditioning appliances shall be installed in accordance with the manufacturer’s installation instructions. Unless the appliance is listed for installation on a combustible surface, such as a floor or roof, or unless the surface is protected in an approved manner, it shall be installed on a surface of noncombustible construction with noncombustible material and surface finish and with no combustible material against the underside thereof. [NFPA 54:10.2.4]

903.2.5 Refrigeration Coils. The installation of refrigeration coils shall be in accordance with Section 903.2.4. [NFPA 54:10.2.5]

903.2.6 Switches in Electrical Supply Line. Means for interrupting the electrical supply to the air-conditioning appliance and to its associated cooling tower (if supplied and installed in a location remote from the air conditioner) shall be provided within sight of and not over 50 feet (15 240 mm) from the air conditioner and the cooling tower. [NFPA 54:10.2.6]

904.0 Central Heating Boilers and Furnaces.

904.1 Location. Central heating furnace and low-pressure boiler installations in bedrooms or bathrooms shall comply with one of the following:

1. Central heating furnaces and low-pressure boilers shall be permitted to be installed in a closet located in the bedroom or bathroom, provided the closet is equipped with a listed, gasketed door assembly, and a listed self-closing device. The self-closing door assembly shall comply with the requirements of Section 904.1.1. The door assembly shall be installed with a threshold and bottom door seal and shall comply with the requirements of Section 904.1.2. Combustion air for such installations shall be obtained from the outdoors. The closet shall be for the exclusive use of the central heating furnace or low-pressure boiler.

2. Central heating furnaces and low-pressure boilers shall be of the direct-vent type.

904.1.1 Self-Closing Doors. Self-closing doors shall swing easily and freely, and shall be equipped with a self-closing device to cause the door to close and latch each time it is opened. The closing mechanism shall not have a hold-open feature.

904.1.2 Gasketing. Gasketing on gasketed doors or frames shall be furnished in accordance with the published listings of the door, frame, or gasketing material manufacturer.

Exception: Where acceptable to the Authority Having Jurisdiction, gasketing of noncombustible or limited-combustible material shall be permitted to be applied to the frame, provided closing and latching of the door are not inhibited.

904.2 Clearance. Central heating furnaces and low-pressure boilers shall be provided with clearances in accordance with Section 904.2.1 through Section 904.2.8. [NFPA 54:10.3.2.6]

904.2.1 Listed Units. Listed central heating furnaces and low-pressure boilers shall be installed with clearances in accordance with the terms of their listings and the manufacturer’s installation instructions.

904.2.2 Unlisted Units. Unlisted central-heating furnaces and low-pressure boilers shall be installed with clearances from combustible material not less than those specified in Table 904.2.2. [NFPA 54:10.3.2.2]

904.2.3 Listed and Unlisted Units. List and unlisted central heating furnaces and low-pressure boilers shall be permitted to be installed with reduced clearances to combustible material, provided that the combustible material or appliance is protected as described in Table 303.10.1 and Figure 303.10.1(1) through Figure 303.10.1(3), and such reduction is allowed by the manufacturer’s installation instructions. [NFPA 54:10.3.2.3]

904.2.4 Front Clearance. Front clearance shall be sufficient for servicing the burner and the furnace or boiler. [NFPA 54:10.3.2.4]

904.2.5 Adjacent to Plaster or Noncombustible Materials. Where the furnace plenum is adjacent to plaster or noncombustible material attached to combustible material, the clearance shall be measured to the surface of the plaster or other noncombustible finish where the clearance specified is 2 inches (51 mm) or less. [NFPA 54:10.3.2.5]

904.2.6 Interference. The clearances to these appliances shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing. [NFPA 54:10.3.2.6]

904.2.7 Central Heating Furnaces. Central heating furnaces other than those listed in Section 904.2.9 shall have clearances from the supply ducts of not less than 18 inches (457 mm) from the furnace plenum for the first 3 feet (914 mm), then 6 inches (152 mm) for the next 3 feet (914 mm) and 1 inch (25.4 mm) beyond 6 feet (1829 mm). [NFPA 54:10.3.2.9]

904.3 Assembly and Installation. A central-heating boiler or furnace shall be installed in accordance with the manufacturer’s instructions in one of the following manners:

1. On a floor of noncombustible construction with noncombustible flooring, and surface finish and with no combustible material against the underside thereof.

2. On fire-resistive slabs or arches having no combustible material against the underside thereof.

Exceptions:

1. Appliances listed for installation on a combustible floor.

2. Installation on a floor protected in an approved manner. [NFPA 54:10.3.3]

904.3.1 Under-Floor Installation. Furnaces installed in an under-floor area of the building shall be in accordance with the Section 904.3.1.1 through Section 904.3.1.3.

904.3.1.1 Supported by Ground. Where a furnace is supported by the ground, it shall be installed on a concrete slab not less than 3 inches (76 mm) above the adjoining ground level.
**904.3.1.2 Supported from Above.** Where a furnace is supported from above, a clearance of not less than 6 inches (152 mm) shall be provided from finished grade.

**904.3.1.3 Excavation.** Where excavation is necessary to install a furnace, it shall be installed in accordance with Section 303.11.

**904.4 Temperature- or Pressure-Limiting Devices.**
Steam and hot water boilers, respectively, shall be provided with approved automatic limiting devices for shutting down the burner(s) to prevent boiler steam pressure or boiler water temperature from exceeding the maximum allowable working pressure or temperature. Safety limit controls shall not be used as operating controls. [NFPA 54:10.3.4]

**904.5 Low-Water Cutoff.** All water boilers and steam boilers shall be provided with an automatic means to shut off the fuel supply to the burner(s) if the boiler water level drops below the lowest safe water line. In lieu of the low-water cutoff, water tube or coil-type boilers that require forced circulation to prevent overheating and failure shall have an approved flow sensing device arranged to shut down the boiler when the flow rate is inadequate to protect the boiler against overheating. [NFPA 54:10.3.5]

**904.6 Steam Safety and Pressure-Relief Valves.**
Steam and hot water boilers shall be equipped, respectively, with listed or approved steam safety or pressure-relief valves of appropriate discharge capacity and conforming with ASME requirements. A shutoff valve shall not be placed between the relief valve and the boiler or on discharge pipes between such valves and the atmosphere. [NFPA 54:10.3.6]

**904.6.1 Discharge.** Relief valves shall be piped to discharge near the floor. [NFPA 54:10.3.6.1]

**904.6.2 Size.** The entire discharged piping shall be not less than the same size as the relief valve discharge piping. [NFPA 54:10.3.6.2]

**904.6.3 End Connections.** Discharge piping shall not contain a threaded end connection at its termination point. [NFPA 54:10.3.6.3]

**904.8.904.7 Refrigeration Coils.** The installation of refrigeration coils shall comply with the following requirements:

1. A refrigeration coil shall not be installed in conjunction with a forced-air furnace where circulation of cooled air is provided by the furnace blower, unless the blower has the capacity to overcome the external static pressure resistance imposed by the duct system and refrigeration coil at the air flow rate for heating or cooling, whichever is greater.

2. Furnaces shall not be located upstream from refrigeration coils, unless the refrigeration coil is designed or equipped so as not to develop excessive temperature or pressure.

3. Refrigeration coils shall be installed in parallel with or on the downstream side of central furnaces to avoid condensation in the heating element, unless the furnace has been specifically listed for downstream installation. With a parallel flow arrangement, the dampers or other means used to control flow of air shall be tight to prevent a circulation of cooled air through the furnace.

4. Means shall be provided for disposal of condensate and to prevent dripping of condensate on the heating element. [NFPA 54:10.3.8]

**904.9 Cooling Units Used with Heating Boilers.**
Boilers, where used in conjunction with refrigeration systems, shall be installed so that the chilled medium is piped in parallel with the heating boiler with appropriate valves to prevent the chilled medium from entering the heating boiler. [NFPA 54:10.3.9.1]

**904.9.1904.8.1 Exposed to Refrigerated Air Circulation.** Where hot-water-heating boilers are connected to heating coils located in air-handling units where they can be exposed to refrigerated air circulation, such boiler piping systems shall be equipped with flow control valves or other automatic means to prevent gravity circulation of the boiler water during the cooling cycle. [NFPA 54:10.3.9.2]

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**TABLE 904.2.2**

**CLEARANCES TO COMBUSTIBLE MATERIAL FOR UNLISTED FURNACES AND BOILERS**

<table>
<thead>
<tr>
<th>APPLIANCE</th>
<th>ABOVE AND SIDES OF FURNACE PLENUM</th>
<th>TOP OF BOILER</th>
<th>JACKET SIDES AND REAR</th>
<th>FRONT</th>
<th>DRAFT HOOD AND BAROMETRIC DRAFT REGULATOR</th>
<th>SINGLE-WALL VENT CONNECTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Automatically fired, forced air or gravity system, equipped with temperature limit control that is not capable of being set to exceed 250°F.</td>
<td>6</td>
<td>–</td>
<td>6</td>
<td>18</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>2. Automatically fired heating boilers – steam boilers operating at not over 15 pounds-force per square inch (psi) and hot water boilers operating at 250°F or less.</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>3. Central heating boilers and furnaces, other than in 1 or 2.</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm, °C = (°F - 32)/1.8, 1 pound-force per square inch = 6.8947 kPa

* See Section 904.1 for additional requirements for central heating boilers and furnaces.
904.10904.9 Furnace (Upright and Horizontal). Upright furnaces shall be permitted to be installed in an attic, furred, or under-floor space exceeding 5 feet (1524 mm) in height, provided the required listings and furnace and duct clearances are observed. Horizontal furnaces shall be permitted to be installed in an attic, furred, or under-floor space, provided the required listings and furnace and duct clearances are observed.

904.10904.10 Solid-Fuel-Fired Furnaces. Factory-built solid-fuel-fired furnaces shall comply with UL 391 and shall be installed in accordance with the manufacturer’s installation instructions.

904.10904.11 Oil-Fired Central Furnaces. Oil-fired central furnaces shall comply with UL 727 and shall be installed in accordance with the manufacturer’s installation instructions.

904.10904.12 Commercial or Industrial Gas Heaters. Commercial or industrial gas-fired heaters shall comply with UL 795 and shall be installed in accordance with the manufacturer’s installation instructions.

904.10904.13 Electric Central Furnaces. Electric central heating furnaces shall comply with UL 1995 or UL 60335-2-40 and shall be installed in accordance with the manufacturer’s installation instructions.

905.0 Duct Furnaces.

905.1 Clearances. The installation of duct furnaces shall comply with the following clearance requirements:

1. Listed duct furnaces shall be installed with clearances of not less than 6 inches (152 mm) between adjacent walls, ceilings, and floors of combustible material and the furnace draft hood. Furnaces listed for installation at lesser clearances shall be installed in accordance with their listings and the manufacturer’s installation instructions. In no case shall the clearance be such as to interfere with combustion air and accessibility.

2. Unlisted duct furnaces shall be installed with clearances to combustible material in accordance with the clearances specified for unlisted furnaces and boilers in Table 904.2.2. Combustible floors under unlisted duct furnaces shall be protected in an approved manner.

905.2 Installation of Duct Furnaces. Duct furnaces shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.10.2]

905.3 Access Panels. The ducts connected to duct furnaces shall have removable access panels on both the upstream and downstream sides of the furnace. [NFPA 54:10.10.3]

905.4 Location of Draft Hoods and Controls. The controls, combustion-air inlet, and draft hoods for duct furnaces shall be located outside the ducts. The draft hood shall be located in the same enclosure from which combustion air is taken. [NFPA 54:10.10.4]

905.5 Circulating Air. Where a duct furnace is installed so that supply ducts carry air circulated by the furnace to areas outside the space containing the furnace, the return air shall also be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace. The duct furnace shall be installed on the positive-pressure side of the circulating air blower. [NFPA 54:10.10.5]

905.6 Duct Furnaces Used with Refrigeration Systems. A duct furnace shall not be installed in conjunction with a refrigeration coil where circulation of cooled air is provided by the blower.

Exception: Where the blower has sufficient capacity to overcome the external static resistance imposed by the duct system, furnace, and the cooling coil and the air throughput necessary for heating or cooling, whichever is greater. [NFPA 54:10.10.6.1]

905.6.1 In Conjunction with Cooling Appliances. Duct furnaces used in conjunction with cooling appliances shall be installed in parallel with or on the upstream side of cooling coils to avoid condensation within heating elements. With a parallel flow arrangement, the dampers or other means used to control the flow of air shall be sufficiently tight to prevent any circulation of cooled air through the unit.

Exception: Where the duct furnace has been specifically listed for downstream installation. [NFPA 54:10.10.6.2]

905.6.2 Located Upstream from Cooling Coils. Where duct furnaces are to be located upstream from cooling units, the cooling unit shall be so designed or equipped as to not develop excessive temperatures or pressures. [NFPA 54:10.10.6.3]

905.6.3 Heat Exchangers. Where a duct furnace is installed downstream of an evaporative cooler or air washer, the heat exchanger shall be constructed of corrosion-resistant materials. Stainless steel, ceramic-coated steel, and an aluminum-coated steel in which the bond between the steel and the aluminum is an iron-aluminum alloy are considered to be corrosion resistant. Air washers operating with chilled water that deliver air below the dew point of the ambient air at the duct furnace shall be considered as refrigeration systems. [NFPA 54:10.10.6.4]

905.7 Installation in Commercial Garages and Aircraft Hangars. Duct furnaces installed in garages for more than three motor vehicles or in aircraft hangars shall be of a listed type and shall be installed in accordance with Section 303.11 and Section 303.12. [NFPA 54:10.10.7]

905.8 Electric Duct Heaters. Electric duct heaters installed within an air duct shall be listed and labeled in accordance with UL 1996 and designed for the maximum air temperature. The duct heater and fan shall be interlocked such that the electric duct heater operates when the fan is operating.

905.8.1 Installation. Duct heaters shall be installed in accordance with the manufacturer’s installation instructions, and shall not create a hazard to persons or property. Where installed 4 feet (1219 mm) or less from a heat pump or air conditioner, the duct heater shall be listed for such installation.

905.8.2 Clearance. A working space clearance shall be maintained to permit replacement of controls and heating elements and for adjusting and cleaning of controls. The working space for energized equipment shall comply with NFPA 70.
906.0 Floor Furnaces.

906.1 Installation. The installation of floor furnaces shall comply with the following requirements:

1) Listed floor furnaces shall be installed in accordance with their listing and the manufacturer’s installation instructions.

2) Unlisted floor furnaces shall not be installed on combustible floors.

3) Thermostats controlling floor furnaces shall not be located in a room or space that is capable of being separated from the room or space in which the register of the floor furnace is located.

906.2 Temperature Limit Controls. Floor furnaces shall be provided with temperature limit controls in accordance with the following requirements:

1) Listed automatically operated floor furnaces shall be equipped with temperature limit controls. [NFPA 54:10.11.2.1]

2) Unlisted automatically operated floor furnaces shall be equipped with a temperature limit control arranged to shut off the flow of gas to the burner in the event the temperature at the warm air outlet register exceeds 350°F (177°C) above room temperature. [NFPA 54:10.11.2.2]

906.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.11.3]

906.4 Placement. The following provisions apply to furnaces that serve one story:

1) Floors. Floor furnaces shall not be installed in the floor of any doorway, stairway landing, aisle, or passageway of any enclosure, public or private, or in an exitway from any such room or space.

2) Walls and Corners. The register of a floor furnace with a horizontal warm air outlet shall not be placed closer than 6 inches (152 mm) from the nearest wall. A distance of at least 18 inches (457 mm) from two adjoining sides of the floor furnace register to walls shall be provided to eliminate the necessity of occupants walking over the warm air discharge. The remaining sides shall be a minimum of 6 inches (152 mm) from a wall. Wall register models shall not be placed closer than 6 inches (152 mm) to a corner.

3) Draperies. The furnace shall be placed so that a door, drapery, or similar object cannot be nearer than 12 inches (305 mm) to any portion of the register of the furnace. [NFPA 54:10.11.4]

906.5 Bracing. The space provided for the furnace shall be framed with doubled joists and with headers not lighter than the joists. [NFPA 54:10.11.5]

906.6 Support. Means shall be provided to support the furnace where the floor register is removed. [NFPA 54:10.11.6]

906.7 Clearance. The lowest portion of the floor furnace shall have at least a 6 inch (152 mm) clearance from the general ground level. A reduced clearance to a minimum of 2 inches (51 mm) shall be permitted, provided the lower 6 inches (152 mm) portion of the floor furnace is sealed by the manufacturer to prevent entrance of water. Where these clearances are not present, the ground below and to the sides shall be excavated to form a “basin-like” pit under the furnace so that the required clearance is provided beneath the lowest portion of the furnace. A 12 inch (305 mm) clearance shall be provided on all sides except the control side, which has shall have an 18 inch (457 mm) clearance. [NFPA 54:10.11.7]

906.8 Access. The space in which a floor furnace is installed shall be accessible by an opening in the foundation not less than 24 inches by 18 inches (610 mm by 457 mm) or by a trap door not less than 24 inches by 24 inches (610 mm by 610 mm) in a cross-section thereof, and a passageway not less than 24 inches by 18 inches (610 mm by 457 mm) in a cross-section thereof. [NFPA 54:10.11.8]

906.9 Seepage Pan. Where the excavation exceeds 12 inches (305 mm) in depth or water seepage is likely to collect, a watertight copper pan, concrete pit, or other approved material shall be used, unless adequate drainage is provided or the appliance is sealed by the manufacturer to meet this condition. A copper pan shall be made of not less than 16 ounces per square foot (oz/ft²) (4.9 kg/m²) sheet copper. The pan shall be anchored in place so as to prevent floating, and the walls shall extend at least 4 inches (102 mm) above the ground level with at least 6 inches (152 mm) clearance on all sides, except on the control side, which shall have at least an 18 inch (457 mm) clearance. [NFPA 54:10.11.9]

906.10 Wind Protection. Floor furnaces shall be protected, where necessary, against severe wind conditions. [NFPA 54:10.11.10]

906.11 Upper-Floor Installations. Listed floor furnaces shall be permitted to be installed in an upper floor, provided the furnace assembly projects below into a utility room, closet, garage, or similar nonhabitable space. In such installations, the floor furnace shall be enclosed completely (entirely separated from the nonhabitable space) with means for air intake to meet the provisions of Section 701.0, with access for servicing, minimum furnace clearances of 6 inches (152 mm) all sides and bottom, and with the enclosure constructed of portland cement plaster or metal lath or other noncombustible material. [NFPA 54:10.11.11]

906.12 First Floor Installation. Listed floor furnaces installed in the first or ground floors of buildings shall not be required to be enclosed unless the basements of these buildings have been converted to apartments or sleeping quarters, in which case the floor furnace shall be enclosed as specified for upper floor installations and shall project into a nonhabitable space. [NFPA 54:10.11.12]

906.13 Oil-Fired Floor Furnaces. Oil-fired floor furnaces shall comply with UL 729 and installed in accordance with the manufacturer’s installation instructions.

907.0 Wall Furnaces.

907.1 Installation. Listed wall furnaces shall be installed in accordance with their listings and the manufacturer’s installation instructions. Wall furnaces installed in or attached to combustible material shall be listed for such installation.

907.1.1 Unlisted Wall Furnaces. Unlisted wall furnaces shall not be installed in or attached to combustible material. [NFPA 54:10.26.1.2]
907.1.2 Vented Wall Furnaces. Vented wall furnaces connected to a Type B-W gas vent system listed only for a single story shall be installed only in single-story buildings or the top story of multistory buildings. Vented wall furnaces connected to a Type B-W gas vent system listed for installation in multistory buildings shall be permitted to be installed in single-story or multistory buildings. Type B-W gas vents shall be attached directly to a solid header plate that serves as a firestop at that point and that shall be permitted to be an integral part of the vented wall furnace, as illustrated in Figure 907.1.2. The stud space in which the vented wall furnace is installed shall be ventilated at the first ceiling level by installation of the ceiling plate spacers furnished with the gas vent. Firestop spacers shall be installed at each subsequent ceiling or floor level penetrated by the vent. [NFPA 54:10.26.1.3]

907.1.3 Direct Vent Wall Furnaces. Direct-vent wall furnaces shall be installed with the vent-air intake terminal in the outdoors. The thickness of the walls on which the furnace is mounted shall be within the range of wall thickness marked on the furnace and covered in the manufacturer’s installation instructions. [NFPA 54:10.26.1.4]

907.1.4 Panels, Grilles, and Access Doors. Panels, grilles, and access doors that are required to be removed for normal servicing operations shall not be attached to the building. For additional information on the venting of wall furnaces, see Section 802.0. [NFPA 54:10.26.1.5]

907.2 Location. Wall furnaces shall be located so as not to cause a hazard to walls, floors, curtains, furniture, or doors. Wall furnaces installed between bathrooms and adjoining rooms shall not circulate air from bathrooms to other parts of the building. [NFPA 54:10.26.2]

907.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.26.3]

907.4 Oil-Fired Wall Furnaces. Oil-fired wall furnaces shall comply with UL 730 and installed in accordance with the manufacturer’s installation instructions.

908.0 Clothes Dryers.

908.1 Electric Clothes Dryers. Commercial electric clothes dryers shall comply with UL 1240 and installed in accordance with the manufacturer’s installation instructions. Residential and coin-operated electric clothes dryers shall comply with UL 2158 and installed in accordance with the manufacturer’s installation instructions.

908.2 Gas-Fired Clothes Dryers. Gas-fired clothes dryers shall comply with Section 908.2.1 through Section 908.2.3.

908.2.1 Clearance. The installation of clothes dryers shall comply with the following requirements:

1. Listed Type 1 clothes dryers shall be installed with a clearance of not less than 6 inches (152 mm) from adjacent combustible material. Clothes dryers listed for installation at reduced clearances shall be installed in accordance with their listing and the manufacturer’s installation instructions. Type 1 clothes dryers installed in closets shall be listed for such installation.

2. Listed Type 2 clothes dryers shall be installed with clearances of not less than that shown on the marking plate and in the manufacturer’s instructions. Type 2 clothes dryers designed and marked, “For use only in noncombustible locations,” shall not be installed elsewhere.

3. Unlisted clothes dryers shall be installed with clearances to combustible material of not less than 18 inches (457 mm). Combustible floors under unlisted clothes dryers shall be protected in an approved manner.

908.2.2 Exhausting to the Outdoors. Type 1 and Type 2 clothes dryers shall be exhausted to the outside air in accordance with Section 504.4.

908.2.3 Multiple-Family or Public Use. Clothes dryers installed for multiple-family or public use shall be equipped with approved safety shutoff devices and shall be installed as specified for a Type 2 clothes dryer in accordance with Section 504.4.3.1. [NFPA 54:10.4.6]
909.0 Conversion Burners.

909.1 General. Installation of conversion burners shall comply with CSA Z21.8. [NFPA 54:10.5]

910.0 Burner Assemblies.

910.1 Oil Burners. Oil burners shall comply with UL 296 and installed in accordance with the manufacturer’s installation instructions.

910.2 Gas Burners. Commercial gas burners shall comply with UL 295 and installed in accordance with the manufacturer’s installation instructions.

911.0 Decorative Appliances for Installation in Vented Fireplaces.

911.1 Prohibited Installations. Decorative appliances for installation in vented fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with Section 701.4. [NFPA 54:10.6.1]

911.2 Installation. A decorative appliance for installation in a vented fireplace shall be installed only in a vented fireplace having a working chimney flue and constructed of noncombustible materials. These appliances shall not be thermostatically controlled. [NFPA 54:10.6.2]

911.2.1 Listed Decorative Appliance. A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer’s installation instructions.

911.2.2 In Manufactured Homes. A decorative appliance for installation in a vented fireplace, where installed in a manufactured home, shall be listed for installation in manufactured homes. [NFPA 54:10.6.2.2]

911.2.3 Unlisted Decorative Appliance. An unlisted decorative appliance for installation in a vented fireplace shall be installed in a fireplace having a permanent free opening, based on appliance input rating and chimney height, equal to or greater than that specified in Table 911.2. [NFPA 54:10.6.2.3]

911.3 Fireplace Screens. A fireplace screen shall be installed with a decorative appliance for installation in a vented fireplace. [NFPA 54:10.6.3]

912.0 Gas Fireplaces, Vented.

912.1 Prohibited Installations. Vented gas fireplaces shall not be installed in bathrooms or bedrooms unless the appliance is listed and the bedroom or bathroom has the required volume in accordance with Section 701.4. [NFPA 54:10.7.1]

Exception: Direct-vent gas fireplaces. [NFPA 54:10.7.1]

912.2 Installation. The installation of vented gas fireplaces shall comply with the following requirements:

1. Listed vented gas fireplaces shall be installed in accordance with their listing and the manufacturer’s installation instructions and where installed in or attached to combustible material shall be specifically listed for such installation.

2. Unlisted vented gas fireplaces shall not be installed in or attached to combustible material. They shall have a clearance at the sides and rear of not less than 18 inches (457 mm). Combustible floors under unlisted vented gas fireplaces shall be protected in an approved manner. Unlisted appliances other than the direct-vent type shall be equipped with a draft hood and shall be vented in accordance with Section 802.0. Appliances that use metal, asbestos, or ceramic material to direct radiation to the front of the appliance shall have a clearance of 36 inches (914 mm) in front and, where constructed with a double back of metal or ceramic, shall be installed with a clearance of not less than 18 inches (457 mm) at the sides and 12 inches (305 mm) at the rear.

3. Panels, grilles, and access doors that are required to be removed for normal servicing operations shall not be attached to the building.

4. Direct-vent gas fireplaces shall be installed with the vent-air intake terminal in the outdoors and in accordance with the manufacturer’s installation instructions.

912.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.7.3]

913.0 Factory-Built Fireplaces and Fireplace Stoves.

913.1 Factory-Built Fireplaces. Factory-built fireplaces shall comply with UL 127 and installed in accordance with the manufacturer’s installation instructions.

913.1.1 Gasketed Fireplace Doors. A gasketed fireplace door shall not be installed on a factory-built fireplace, except where the fireplace system has been tested in accordance with UL 127.

913.2 Fireplace Stoves. Fireplace stoves shall comply with UL 737 and installed in accordance with the manufacturer’s installation instructions.

913.3 Fireplace Accessories. Heat exchangers, glass doors assemblies, combustion air vents, and termination caps shall comply with UL 907 and installed in accordance with the manufacturer’s installation instructions.

914.0 Non-Recirculating Direct Gas-Fired Industrial Air Heaters.

914.1 Application. Direct gas-fired industrial air heaters of the non-recirculating type shall be listed in accordance with CSA Z83.4. [NFPA 54:10.8.1]

914.2 Prohibited Installations. Non-recirculating direct gas-fired industrial air heaters shall not serve any area containing sleeping quarters. Non-recirculating direct gas-fired industrial air heaters shall not recirculate room air. [NFPA 54:10.8.2.1, 10.8.2.2]

914.3 Installation. Non-recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer’s instructions. [NFPA 54:10.8.3.1]

914.3.1 Industrial or Commercial Occupancies. Non-recirculating direct gas-fired industrial air heaters shall be installed only in industrial or commercial occupancies. [NFPA 54:10.8.3.2]
**914.3.1 Fresh Air Ventilation.** Non-recirculating direct gas-fired industrial air heaters shall be permitted to provide fresh air ventilation. [NFPA 54:10.8.3.3-10.8.3.2]

**914.3.2 Access Required.** Non-recirculating direct gas-fired industrial air heaters shall be provided with access for removal of burners; for replacement of motors, controls, filters, and other working parts; and for adjustment and lubrication of parts requiring maintenance. [NFPA 54:10.8.3.4]

**914.4 Clearance from Combustible Materials.** Non-recirculating direct gas-fired industrial air heaters shall be installed with a clearance from combustible materials of not less than that shown on the rating plate and the manufacturer’s installation instructions. [NFPA 54:10.8.5]

**914.5 Air Supply.** All air to the non-recirculating direct gas-fired industrial air heater shall be ducted directly from outdoors. Where outdoor air dampers or closing louvers are used, they shall be verified to be in the open position prior to main burner operation. [NFPA 54:10.8.6]

**914.6 Atmospheric Vents, Gas Reliefs, or Bleeds.** Non-recirculating direct gas-fired industrial air heaters with valve train components equipped with atmospheric vents, gas reliefs, or bleeds shall have their vent lines, gas reliefs, or bleeds lead to a safe point outdoors. Means shall be employed on these lines to prevent water from entering and to prevent blockage from insects and foreign matter. An atmospheric vent line shall not be required to be provided on a valve train component equipped with a listed vent limiter. [NFPA 54:10.8.7]

**914.7 Relief Openings.** The design of the installation shall include adequate provisions to permit the non-recirculating direct gas-fired industrial air heater to operate at its rated airflow without overpressurizing the space served by the heater by taking into account the structure’s designed infiltration rate, properly designed relief openings; or an interlocked powered exhaust system; or a combination of these methods. [NFPA 54:10.8.8]

**914.7.1 Infiltration Rate.** The structure’s designed infiltration rate and the size of relief opening(s) shall be determined by approved engineering methods. [NFPA 54:10.8.7.1]

**914.7.2 Louver or Gravity Dampers.** Louver or counterbalanced gravity damper relief openings shall be permitted. Where motorized dampers or closeable louvers are used, they shall be proved to be in their open position prior to main burner operation. [NFPA 54:10.8.7.2]

**914.8 Purging.** Inlet ducting, when used, shall be purged with not less at least four air changes prior to an ignition attempt. [NFPA 54:10.8.8]

**915.0 Recirculating Direct Gas-Fired Industrial Air Heaters.**

**915.1 Application.** Direct gas-fired industrial air heaters of the recirculating type shall be listed in accordance with CSA Z83.18. [NFPA 54:10.9.1]

**915.2 Prohibited Installations.** Recirculating direct gas-fired industrial air heaters shall not serve any area containing sleeping quarters. Recirculating direct gas-fired industrial air heaters shall not recirculate room air in buildings that contain flammable solids, liquids, or gases; explosive materials; or substances that can become toxic when exposed to flame or heat. [NFPA 54:10.9.2.1, 10.9.2.2]

**915.3 Installation.** Installation of direct gas-fired industrial air heaters shall comply with the following requirements:

1. Recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer’s installation instructions.

2. Recirculating direct gas-fired industrial air heaters shall be installed in industrial or commercial occupancies. [NFPA 54:10.9.3]

**915.4 Clearance from Combustible Materials.** Recirculating direct gas-fired industrial air heaters shall be installed with a clearance from combustible materials of not less than that shown on the rating plate and the manufacturer’s installation instructions. [NFPA 54:10.9.4]

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### TABLE 911.2

**FREE OPENING AREA OF CHIMNEY DAMPER FOR VENTING FLUE GASES FROM UNLISTED DECORATIVE APPLIANCES FOR INSTALLATION IN VENTED FIREPLACES**

[NFPA 54: TABLE 10.6.2.3]

<table>
<thead>
<tr>
<th>CHIMNEY HEIGHT (feet)</th>
<th>MINIMUM PERMANENT FREE OPENING (square inches)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>7800</td>
</tr>
<tr>
<td>8</td>
<td>8400</td>
</tr>
<tr>
<td>10</td>
<td>9000</td>
</tr>
<tr>
<td>15</td>
<td>9800</td>
</tr>
<tr>
<td>20</td>
<td>10 600</td>
</tr>
<tr>
<td>30</td>
<td>11 200</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* The first six minimum permanent free openings [8 square inches (0.005 m²) to 51 square inches (0.03 m²)] correspond approximately to the cross-sectional areas of chimneys having diameters of 3 inches (76 mm) through 8 inches (203 mm), respectively. The 64 square inch (0.04 m²) opening corresponds to the cross-sectional area of a standard 8 inch (203 mm) by 8 inch (203 mm) chimney tile.
915.5 Air Supply. Ventilation air to the recirculating direct gas-fired industrial air heater shall be ducted directly from outdoors. Air to the recirculating direct gas-fired industrial air heater in excess of the minimum ventilation air specified on the heater’s rating plate shall be taken from the building, ducted directly from outdoors, or a combination of both. Where outdoor air dampers or closing louvers are used, they shall be verified to be in the open position prior to main burner operation. [NFPA 54:10.9.5]

915.6 Atmospheric Vents, Gas Reliefs, or Bleeds. Recirculating direct gas-fired industrial air heaters with valve train components equipped with atmospheric vents, gas reliefs, or bleeds shall have their vent lines, gas reliefs, or bleeds lead to a safe point outdoors. Means shall be employed on these lines to prevent water from entering and to prevent blockage from insects and foreign matter. An atmospheric vent line shall not be required to be provided on a valve train component equipped with a listed vent limiter. [NFPA 54:10.9.6]

915.7 Relief Openings. The design of the installation shall include adequate provisions to permit the recirculating direct gas-fired industrial air heater to operate at its rated airflow without overpressurizing the space served by the heater by taking into account the structure’s designed infiltration rate, properly designed relief openings or an interlocked powered exhaust system, or a combination of these methods. [NFPA 54:10.9.7]

915.7.1 Infiltration Rate. The structure’s designed infiltration rate and the size of relief opening(s) shall be determined by approved engineering methods. [NFPA 54:10.9.7.1]

915.7.2 Louver or Gravity Dampers. Louver or counterbalanced gravity damper relief openings shall be permitted. Where motorized dampers or closeable louvers are used, they shall be proved to be in their open position prior to main burner operation. [NFPA 54:10.9.7.2]

915.8 Purging. Inlet ducting, where when used, shall be purged with not less than at least four air changes prior to an ignition attempt. [NFPA 54:10.9.8]

916.0 Room Heaters.

916.1 Electric Room Heaters. Electric room heaters shall comply with UL 2021.

916.2 Gas-Fired Room Heaters. Gas-fired room heaters shall comply with Section 916.2.1 through Section 916.2.4.

916.2.1 Prohibited Installations. Unless specifically permitted by the Authority Having Jurisdiction, unvented room heaters shall not be installed as primary heat sources. Unvented room heaters shall not be permitted in spaces that do not have the required volume of indoor air as defined in Section 701.4.

916.2.1.1 Unvented Room Heaters. Unvented room heaters shall not be installed in bathrooms or bedrooms.

Exceptions:

(1) Where approved by the Authority Having Jurisdiction, one listed wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff system shall be permitted to be installed in a bathroom, provided that the input rating does not exceed 6000 Btu/h (1.76 kW) and combustion and ventilation air is provided as specified in Section 902.2.

(2) Where approved by the Authority Having Jurisdiction, one listed wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff system shall be permitted to be installed in a bedroom, provided that the input rating does not exceed 10 000 Btu/h (3 kW) and combustion and ventilation air is provided as specified in Section 902.2. [NFPA 54:10.22.1]

(3) Portable oil fired unvented heating appliances used as supplemental heating in storage occupancies, utility occupancies, and in accordance with the fire code.

916.2.2 Installations in Institutions. Room heaters shall not be installed in the following occupancies:

(1) Residential board and care

(2) Health care [NFPA 54:10.22.3]

916.2.3 Clearance. A room heater shall be placed so as not to cause a hazard to walls, floors, curtains, furniture, doors where open, and to the free movements of persons within the room. Heaters designed and marked, “For use in noncombustible fireplace only,” shall not be installed elsewhere. Listed room heaters shall be installed in accordance with their listings and the manufacturer’s installation instructions. In no case shall the clearances be such as to interfere with combustion air and accessibility. Unlisted room heaters shall be installed with clearances from combustible material not less than the following:

(1) Circulating type room heaters having an outer jacket surrounding the combustion chamber, arranged with openings at top and bottom so that air circulates between the inner and outer jacket, and without openings in the outer jacket to permit direct radiation, shall have clearance at sides and rear of not less than 12 inches (305 mm).

(2) Radiating type room heaters other than those of the circulating type described in Section 916.2.3(1) shall have clearance at sides and rear of not less than 18 inches (457 mm), except that heaters that make use of metal, asbestos, or ceramic material to direct radiation to the front of the heater shall have a clearance of 36 inches (914 mm) in front and, where constructed with a double back of metal or ceramic, shall be permitted to be installed with a clearance of 18 inches (457 mm) at sides and 12 inches (305 mm) at rear. Combustible floors under unlisted room heaters shall be protected in an approved manner.

916.2.4 Wall-Type Room Heaters. Wall-type room heaters shall not be installed in or attached to walls of combustible material unless listed for such installation. [NFPA 54:10.22.5]

916.3 Solid-Fuel-Type Room Heaters. Solid-fuel type room heaters shall comply with UL 1482.
INSTALLATION OF SPECIFIC APPLIANCES

917.0 Unit Heaters.

917.1 Support. Suspended-type unit heaters shall be safely and adequately supported, with due consideration given to their weight and vibration characteristics. Hangers and brackets shall be of noncombustible material. [NFPA 54:10.25.1]

917.2 Clearance. Suspended-type unit heaters shall comply with the following requirements:

1. A listed unit heater shall be installed with clearances from combustible material of not less than 18 inches (457 mm) at the sides, 12 inches (305 mm) at the bottom, and 6 inches (152 mm) above the top where the unit heater has an internal draft hood, or 1 inch (25.4 mm) above the top of the sloping side of a vertical draft hood. A unit heater listed for reduced clearances shall be installed in accordance with its listing and the manufacturer’s installation instructions.

2. Unlisted unit heaters shall be installed with clearances to combustible material of not less than 18 inches (457 mm).

3. Clearances for servicing shall be in accordance with the manufacturer’s installation instructions.

917.2.1 Floor-Mounted-Type Unit Heaters. Floor-mounted-type unit heaters shall comply with the following requirements:

1. A listed unit heater shall be installed with clearances from combustible material at the back and one side of not less than 6 inches (152 mm). Where the flue gases are vented horizontally, the 6 inch (152 mm) clearance shall be measured from the draft hood or vent instead of the rear wall of the unit heater. A unit heater listed for reduced clearances shall be installed in accordance with its listing and the manufacturer’s installation instructions.

2. Floor-mounted-type unit heaters installed on combustible floors shall be listed for such installation.

3. Combustible floors under unlisted floor-mounted unit heaters shall be protected in an approved manner.

4. Clearances for servicing shall be in accordance with the manufacturer’s instructions.

917.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.25.3]

917.4 Ductwork. A unit heater shall not be attached to a warm air duct system unless listed and marked for such installation. [NFPA 54:10.25.4]

917.5 Installation in Commercial Garages and Aircraft Hangars. Unit heaters installed in garages for more than three motor vehicles or in aircraft hangars shall be of a listed type and shall be installed in accordance with Section 303.11 and Section 303.12. [NFPA 54:10.25.5]

917.6 Oil-Fired Unit Heaters. Oil-fired unit heaters shall comply with UL 731 and installed in accordance with the manufacturer’s installation instructions.

918.0 Food Service Appliance, Floor-Mounted.

918.1 Clearance for Listed Appliances. Listed floor-mounted food service appliances, such as ranges for hotels and restaurants, deep-fat fryers, unit broilers, kettles, steam cookers, steam generators, and baking and roasting ovens, shall be installed not less than 6 inches (152 mm) from combustible material except that not less than at least a 2 inch (51 mm) clearance shall be maintained between a draft hood and combustible material. Floor-mounted food service appliances listed for installation at lesser clearances shall be installed in accordance with its listing and the manufacturer’s installation instructions. Appliances designed and marked, “For use only in noncombustible locations,” shall not be installed elsewhere.

918.2 Clearance for Unlisted Appliances. Unlisted floor-mounted food service appliances shall be installed to provide a clearance to combustible material of not less than 18 inches (457 mm) from the sides and rear of the appliance and from the vent connector and not less than 48 inches (1219 mm) above cooking tops and at the front of the appliance.

Cleargances for unlisted appliances installed in partially enclosed areas such as alcoves shall not be reduced. Reduced clearances for unlisted appliances installed in rooms that are not partially enclosed shall be in accordance with Table 303.10.1. [NFPA 54:10.12.2]

918.3 Mounting on Combustible Floors. Listed floor-mounted food service appliances that are listed specifically for installation on floors constructed of combustible material shall be permitted to be installed on combustible floors in accordance with its listing and the manufacturer’s installation instructions.

918.3.1 Not Listed For Mounting on Combustible Floors. Floor-mounted food service appliances that are not listed for mounting on a combustible floor shall be mounted in accordance with Section 918.4 or be mounted in accordance with one of the following:

1. Where the appliance is set on legs that provide not less than 18 inches (457 mm) open space under the base of the appliance or where it has no burners and no portion of any oven or broiler within 18 inches (457 mm) of the floor, it shall be permitted to be mounted on a combustible floor without special floor protection, provided at least one sheet metal baffle is between the burner and the floor.

2. Where the appliance is set on legs that provide not less than 8 inches (203 mm) open space under the base of the appliance, it shall be permitted to be mounted on combustible floors, provided the floor under the appliance is protected with not less than 3⁄8 of an inch (9.5 mm) insulating millboard covered with sheet metal not less than 0.0195 of an inch (0.4953 mm) thick. The preceding specified floor protection shall extend not less than 6 inches (152 mm) beyond the appliance on all sides.

3. Where the appliance is set on legs that provide not less than 4 inches (102 mm) under the base of the appliance, it shall be permitted to be mounted on combustible floors, provided the floor under the
appliance is protected with hollow masonry not less than 4 inches (102 mm) in thickness covered with sheet metal not less than 0.0195 of an inch (0.4953 mm) thick. Such masonry courses shall be laid with ends unsealed and joints matched in such a way as to provide for free circulation of air through the masonry.

(4) Where the appliance does not have legs at least 4 inches (102 mm) high, it shall be permitted to be mounted on combustible floors, provided the floor under the appliance is protected by two courses of 4 inch (102 mm) hollow clay tile, or equivalent, with courses laid at right angles and with ends unsealed and joints matched in such a way as to provide for free circulation of air through such masonry courses, and covered with steel plate not less than 3/8 of an inch (4.8 mm) in thickness. [NFPA 54:10.12.3.2]

919.4 Installation on Noncombustible Floors. Listed floor-installed food service appliances that are designed and marked “For use only in noncombustible locations” shall be installed on floors of noncombustible construction with noncombustible flooring and surface finish and with no combustible material against the underside thereof, or on noncombustible slabs or arches having no combustible material against the underside thereof. Such construction shall in all cases extend not less than 12 inches (305 mm) beyond the appliance on all sides. [NFPA 54:10.12.4.1, 10.12.4.2]

919.5 Combustible Material Adjacent to Cooking Top. Listed and unlisted food service ranges shall be installed to provide clearance to combustible material not less than 18 inches (457 mm) horizontally for a distance of up to 2 feet (610 mm) above the surface of the cooking top where the combustible material is not completely shielded by high shelving, warming closet, or other system. Reduced combustible material clearances are permitted where protected in accordance with Table 303.10.1. [NFPA 54:10.12.5]

919.6 Use with Casters. Floor-mounted appliances with casters shall be listed for such construction and shall be installed in accordance with the manufacturer’s installation instructions for limiting the movement of the appliance to prevent strain on the connection. [NFPA 54:10.12.6]

919.7 Level Installation. Floor-mounted food service appliances shall be installed level on a firm foundation. [NFPA 54:10.12.7]

919.8 Ventilation. Means shall be provided to properly ventilate the space in which a food service appliance is installed to permit proper combustion of the gas. [NFPA 54:10.12.8]

919.0 Food Service Appliances, Counter Appliances.  
919.1 Vertical Clearance. A vertical distance of not less than 48 inches (1219 mm) shall be provided between the top of food service hot plates and griddles and combustible material. [NFPA 54:10.13.1]

919.2 Clearance for Listed Appliances. Listed food service counter appliances such as hot plates and griddles, food and dish warmers, and coffee brewers and urns, where installed on combustible surfaces, shall be set on their own bases or legs and shall be installed with a horizontal clearance of not less than 6 inches (152 mm) from combustible material, except that not less than a 2 inches (51 mm) clearance shall be maintained between a draft hood and combustible material. Food service counter appliances listed for installation at lesser clearances shall be installed in accordance with their listing and the manufacturer’s installation instructions.

919.3 Clearance for Unlisted Appliances. Unlisted food service hot plates and griddles shall be installed with a horizontal clearance from combustible material of not less than 18 inches (457 mm). Unlisted gas food service counter appliances, including coffee brewers and urns, waffle bakers, and hot water immersion sterilizers, shall be installed with a horizontal clearance from combustible material of not less than 12 inches (305 mm). Reduced clearances for gas food service counter appliances shall be in accordance with Table 303.10.1. Unlisted food and dish warmers shall be installed with a horizontal clearance from combustible material of not less than 6 inches (152 mm). [NFPA 54:10.13.3]

919.4 Mounting of Unlisted Appliances. Unlisted food service counter appliances shall not be set on combustible material unless they have legs that provide not less than 4 inches (102 mm) of open space below the burners and the combustible surface is protected with insulating millboard not less than 3/8 of an inch (6.4 mm) thick covered with sheet metal not less than 0.0122 of an inch (0.3099 mm) thick, or with equivalent protection. [NFPA 54:10.13.4]

920.0 Household Cooking Appliances.  
920.1 Electric Household Cooking Appliances. Electric household cooking appliances designed for permanent installations shall be installed in accordance with the manufacturer’s installation instructions. Household electric ranges shall comply with UL 858.

920.2 Gas-Fired Household Cooking Appliances. Gas-fired household cooking appliances shall comply with Section 920.3 though Section 920.4.920.4.3.

920.3 Floor-Mounted Units. Floor mounted units shall be installed in accordance with Section 920.3.1 and Section 920.3.2.

920.3.1 Clearance from Combustible Material. The clearances specified as follows shall not interfere with combustion air, accessibility for operation, and servicing:

(1) Listed floor-mounted household cooking appliances, where installed on combustible floors, shall be set on their own bases or legs and shall be installed in accordance with their listing and the manufacturer’s installation instructions.

(2) Listed household cooking appliances with listed gas room heater sections shall be installed so that the warm air discharge side shall have a clearance of not less than 18 inches (457 mm) from adjacent combustible material. A clearance of not less than 36 inches (914 mm) shall be provided between the top of the heater section and the bottom of cabinets.
(3) Listed household cooking appliances that include a solid or liquid fuel-burning section shall be spaced from combustible material and otherwise installed in accordance with their listing and the manufacturer’s installation instructions for the supplementary fuel section of the appliance.

(4) Unlisted floor-mounted household cooking appliances shall be installed with not less than 6 inches (152 mm) clearance at the back and sides to combustible material. Combustible floors under unlisted appliances shall be protected in an approved manner.

920.4 Built-In Units. Built-in units shall be installed in accordance with Section 920.4.1 through Section 920.4.4.

920.4.1 Installation. Listed built-in household cooking appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions. The installation shall not interfere with combustion air, accessibility for operation, and servicing. Unlisted built-in household cooking appliances shall not be installed in or adjacent to combustible material.

920.4.2 Vertical Clearance. Built-in top (or surface) cooking appliances shall have a vertical clearance above the cooking top of not less than 30 inches (762 mm) to combustible material or metal cabinets. A minimum clearance of 24 inches (610 mm) is permitted where one of the following is installed:

1. The underside of the combustible material or metal cabinet above the cooking top is protected with not less than ¼ of an inch (6.4 mm) insulating millboard covered with sheet metal not less than 0.0122 of an inch (0.3099 mm) thick.

2. A metal ventilating hood of sheet metal not less than 0.0122 of an inch (0.3099 mm) thick is installed above the cooking top with a clearance of not less than ¼ of an inch (6.4 mm) between the hood and the underside of the combustible material or metal cabinet, and the hood not less than the width of the appliance and is centered over the appliance.

3. A listed cooking appliance or microwave oven installed over a listed cooking appliance shall be in accordance with the terms of the upper appliance’s listing and the manufacturer’s installation instructions. Microwave ovens shall comply with UL 923.

920.4.3 Horizontal Clearance. The horizontal distance from the center of the burner head(s) of a listed top (or surface) cooking appliance to vertical combustible walls extending above the top panel shall be not less than that distance specified by the permanent marking on the appliance. [NFPA 54:10.15.2.3]

920.4.4 Level Installation. Built-in household cooking appliances shall be installed so that the cooking top, broiler pan, or oven racks are level. [NFPA 54:10.15.2.4.1.3]

920.0 Cooking Appliances Listing.

921.1 Commercial Electric Ranges. Commercial electric ranges shall comply with UL 197 and installed in accordance with the manufacturer’s installation instructions.

921.2 Commercial Wood-Fired Baking Ovens. Commercial wood-fired baking ovens (refractory type) shall comply with UL 2162 and installed in accordance with the manufacturer’s installation instructions.

921.3 Oil-Burning Ranges. Oil-burning ranges shall comply with UL 896 and installed in accordance with the manufacturer’s installation instructions.

922.0 Open-Top Broiler Units.

922.1 Listed Units. Listed open-top broiler units shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.18.1]

922.2 Unlisted Units. Unlisted open-top broiler units shall be installed in accordance with the manufacturer’s instructions but shall not be installed in combustible material. [NFPA 54:10.18.2]

922.3 Protection Above Domestic Units. Domestic open-top broiler units shall be provided with a metal ventilating hood not less than 0.0122 of an inch (0.3099 mm) thick with a clearance of not less than ¼ of an inch (6.4 mm) between the hood and the underside of combustible material or metal cabinets. A clearance of at least 24 inches (610 mm) shall be maintained between the cooking top and the combustible material or metal cabinet, and the hood shall be at least as wide as the open-top broiler unit and centered over the unit. Listed domestic open-top broiler units incorporating an integral exhaust system and listed for use without a ventilating hood shall not be required to be provided with a ventilating hood if installed in accordance with Section 920.3.2(1). [NFPA 54:10.18.3]
922.4 Commercial Units. Commercial open-top broiler units shall be provided with ventilation in accordance with NFPA 96, Chapter 5, Part II. [NFPA 54:10.18.4]

923.0 Outdoor Cooking Appliances.
923.1 Listed Units. Listed outdoor cooking appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions.
923.2 Unlisted Units. Unlisted outdoor cooking appliances shall be installed outdoors with clearances to combustible material of not less than 36 inches (914 mm) at the sides and back and not less than 48 inches (1219 mm) at the front. In no case shall the appliance be located under overhead combustible construction. [NFPA 54:10.19.2]

924.0 Illuminating Appliances.
924.1 Clearances for Listed Appliances. Listed illuminating appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions.
924.2 Clearances for Unlisted Appliances. Clearances for unlisted illuminating appliances shall comply with the following:

1. Unlisted enclosed illuminating appliances shall be installed with clearances in any direction from combustible material of not less than 12 inches (305 mm). [NFPA 54:10.15.2.1(1)]
2. Unlisted enclosed illuminating appliances installed outdoors shall be installed with clearances in any direction from combustible material of not less than 18 inches (457 mm). [NFPA 54:10.15.2.1(2)]

924.2.1 Open-Flame Type. Clearances shall comply with the following:

1. Unlisted open-flame illuminating appliances installed outdoors shall have clearances from combustible material not less than that specified in Table 924.2.1. The distance from ground level to the base of the burner shall be a minimum of 7 feet (2134 mm) where installed within 2 feet (610 mm) of walkways. Lesser clearances shall be permitted to be used where acceptable to the Authority Having Jurisdiction.
2. Unlisted open-flame illuminating appliances installed outdoors shall be equipped with a limiting orifice or other limiting devices that will maintain a flame height consistent with the clearance from combustible material, as given in Table 924.2.1.
3. Appliances designed for flame heights in excess of 30 inches (762 mm) shall be permitted to be installed if acceptable to the Authority Having Jurisdiction. Such appliances shall be equipped with a safety shutoff device or automatic ignition.
4. Unlisted open-flame illuminating appliances installed indoors shall have clearances from combustible material acceptable to the Authority Having Jurisdiction. [NFPA 54:10.15.2.2]

924.3 Mounting on Buildings. Illuminating appliances designed for wall or ceiling mounting shall be securely attached to substantial structures in such a manner that they are not dependent on the gas piping for support. [NFPA 54:10.15.3]

924.4 Mounting on Posts. Illuminating appliances designed for post mounting shall be securely and rigidly attached to a post. Posts shall be rigidly mounted. The strength and rigidity of posts greater than 3 feet (914 mm) in height shall be at least equivalent to that of a 2½ inch (64 mm) diameter post constructed of 0.064 of an inch (1.626 mm) thick steel or a 1 inch (25.4 mm) Schedule 40 steel pipe. Posts 3 feet (914 mm) or less in height shall not be smaller than a 3/4 of an inch (19.1 mm) Schedule 40 steel pipe. Drain openings shall be provided near the base of posts where water collecting inside the posts is possible. [NFPA 54:10.15.4]

924.5 Appliance Pressure Regulators. Where an appliance pressure regulator is not supplied with an illuminating appliance and the service line is not equipped with a service pressure regulator, an appliance pressure regulator shall be installed in the line serving one or more illuminating appliances. [NFPA 54:10.15.5]

925.0 Incinerators and Crematories.
925.1 Field Constructed Commercial-Industrial Incinerators. Field constructed commercial-industrial incinerators shall be constructed and installed in accordance with NFPA 82.

925.2 Factory-Built Commercial Crematories. Factory-built commercial incinerators and crematories shall comply with UL 2790 and installed in accordance with the manufacturer’s installation instructions.

925.3 Residential Incinerators. Residential incinerators shall comply with UL 791 and installed in accordance with the manufacturer’s installation instructions.

926.0 Infrared Heaters.
926.1 Support. Suspended-type infrared heaters shall be fixed in position independent of gas and electric supply lines. Hangers and brackets shall be of noncombustible material. Heaters subject to vibration shall be provided with vibration-isolating hangers. [NFPA 54:10.17.1]
926.2 Clearance. The installation of infrared heaters shall comply with the following clearance requirements:

(1) Listed heaters shall be installed with clearances from combustible material in accordance with their listing and the manufacturer’s installation instructions.

(2) Unlisted heaters shall be installed in accordance with clearances from combustible material acceptable to the Authority Having Jurisdiction.

(3) In locations used for the storage of combustible materials, signs shall be posted to specify the maximum permissible stacking height to maintain required clearances from the heater to the combustibles.

926.3 Combustion and Ventilation Air. Where unvented infrared heaters are used, natural or mechanical means shall be provided to supply and exhaust at least 4 ft³/min/1000 Btu/h (0.38 m³/min/kW) input of installed heaters. [NFPA 54:10.17.3.1]

926.3.1 Exhaust Openings. Exhaust openings for removing flue products shall be above the level of the heaters. [NFPA 54:10.17.3.2]

926.4 Installation in Commercial Garages and Aircraft Hangars. Overhead heaters installed in garages for more than three motor vehicles or in aircraft hangars shall be of a listed type and shall be installed in accordance with Section 303.11 and Section 303.12. [NFPA 54:10.17.4]

927.0 Pool Heaters.

927.1 Location. A pool heater shall be located or protected so as to minimize accidental contact of hot surfaces by persons. [NFPA 54:10.20.1]

927.2 Clearance. The installation of pool heaters shall comply with the following requirements:

(1) In no case shall the clearances be such as to interfere with combustion air, draft hood, or vent terminal clearance and relief, and accessibility for servicing.

(2) A listed pool heater shall be installed in accordance with its listing and the manufacturer’s installation instructions.

(3) An unlisted pool heater shall be installed with a clearance of not less than 12 inches (305 mm) on the sides and the rear. A combustible floor under an unlisted pool heater shall be protected in an approved manner.

927.3 Temperature or Pressure-Limiting Devices. An unlisted pool heater shall be provided with overtemperature protection or overpressure protection by means of an approved device(s). [NFPA 54:10.20.3.1]

927.3.1 Pressure Relief Valve. Where a pool heater is provided with over-temperature protection only and is installed with any device in the discharge line of the heater that can restrict the flow of water from the heater to the pool (such as a check valve, shutoff valve, therapeutic pool valving, or flow nozzles), a pressure-relief valve shall be installed either in the heater or between the heater and the restrictive device. [NFPA 54:10.20.3.2]

927.4 Bypass Valves. Where an integral bypass system is not provided as a part of the pool heater, a bypass line and valve shall be installed between the inlet and outlet piping for use in adjusting the flow of water through the heater. [NFPA 54:10.20.4]

927.5 Venting. A pool heater listed for outdoor installation shall be installed with the venting means supplied by the manufacturer and in accordance with the manufacturer’s installation instructions. [NFPA 54:10.20.5]

928.0 Refrigerators.

928.1 Clearance. Refrigerators shall be provided with clearances for ventilation at the top and back in accordance with the manufacturer’s instructions. Where such instructions are not available, at least 2 inches (51 mm) shall be provided between the back of the refrigerator and the wall at least 12 inches (305 mm) above the top. [NFPA 54:10.21.1]

928.2 Venting or Ventilating Kits Approved for Use with a Refrigerator. Where an accessory kit is used for conveying air for burner combustion or unit cooling to the refrigerator from areas outside the room in which it is located, or for conveying combustion products diluted with air containing waste heat from the refrigerator to areas outside the room in which it is located, the kit shall be installed in accordance with the refrigerator manufacturer’s instructions. [NFPA 54:10.21.2]

929.0 Gas-Fired Toilets.

929.1 Clearance. A listed gas-fired toilet shall be installed in accordance with its listing and the manufacturer’s installation instructions, provided that the clearance shall be such to afford ready accessibility for use, cleanout, and necessary servicing.

929.2 Installation on Combustible Floors. Listed gas-fired toilets installed on combustible floors shall be listed for such installation. [NFPA 54:10.24.2]

929.3 Vents. Vents or vent connectors that are capable of being contacted during casual use of the room in which the toilet is installed shall be protected or shielded to prevent such contact. [NFPA 54:10.24.3]

930.0 Appliances for Installation in Manufactured Housing.

930.1 General. Appliances installed in manufactured housing after the initial sale shall be listed for installation in manufactured housing, or approved, and shall be installed in accordance with the requirements of this code and the manufacturer’s installation instructions. Appliances installed in the living space of manufactured housing shall be in accordance with the requirements of Section 701.0. [NFPA 54:10.29]

931.0 Small Ceramic Kilns.

931.1 General. The provisions of this section apply to kilns used for ceramics that have a maximum interior volume of 20 cubic feet (0.57 m³) and are used for hobby or noncommercial purposes.

931.2 Installation. Kilns shall be installed in accordance with the manufacturer’s installation instructions and the provisions of this code.
931.3 Fuel-Gas Controls. Fuel-gas controls shall comply with Section 306.0 and Section 902.4. Standing pilots shall not be used with gas-fired kilns.

931.4 Electrical Equipment. All electrical equipment used as part of, or in connection with, the installation of a kiln shall be in accordance with the requirements in the electrical code. Electric kilns shall be listed and labeled in accordance with UL 499.

931.5 Installations Inside Buildings. In addition to other requirements specified in this section, interior installations shall comply with the requirements of Section 603.13.6 and Section 931.5.1 through Section 931.5.5.

931.5.1 Kiln Clearances. The sides and tops of kilns shall be located not less than 18 inches (457 mm) from a noncombustible wall surface and 3 feet (914 mm) from a combustible wall surface. Kilns shall be installed on noncombustible flooring consisting of not less than 2 inches (51 mm) of solid masonry or concrete extending not less than 12 inches (305 mm) beyond the base or supporting members of the kiln.

Exception: These clearances shall be permitted to be reduced, provided the kiln is installed in accordance with its listing.

In no case shall the clearance on the gas or electric control side of a kiln be reduced to less than 30 inches (762 mm).

931.5.2 Hoods. A canopy-type hood shall be installed directly above each kiln. The face opening area of the hood shall be equal to or greater than the top horizontal surface area of the kiln. The hood shall be constructed of not less than 0.024 of an inch (0.61 mm) (No. 24 gauge) galvanized steel or equivalent and be supported at a height of between 12 inches (305 mm) and 30 inches (762 mm) above the kiln by noncombustible supports.

Exception: Electric kilns installed with listed exhaust blowers shall be permitted to be used where marked as being suitable for the kiln and installed in accordance with the manufacturer’s installation instructions.

931.5.3 Gravity Ventilation Ducts. Each hood shall be connected to a gravity ventilation duct extending in a vertical direction to outside the building. This duct shall be of the same construction as the hood and shall have a minimum cross-sectional area of not less than one-fifteenth of the face opening area of the hood. The duct shall terminate not less than 12 inches (305 mm) above a portion of a building within 4 feet (1219 mm) and terminate not less than 4 feet (1219 mm) from an openable window or other opening into the building or adjacent property line. The duct opening to the outside shall be shielded, without reduction of duct area, to prevent entrance of rain into the duct. The duct shall be supported at each section by noncombustible supports.

931.5.4 Makeup Air. Provisions shall be made for air to enter the room in which a kiln is installed at a rate not less than the air being removed through the kiln hood.

931.6 Exterior Installations. Kilns shall be installed with minimum clearances as specified in Section 931.5.1. Wherever a kiln is located under a roofed area and is partially enclosed by more than two vertical wall surfaces, a hood and gravity ventilation duct shall be installed in accordance with Section 931.5.2, Section 931.5.3, and Section 931.5.5.

932.0 Outdoor Open Flame Decorative Appliances.

932.1 General. Permanently fixed in place outdoor open flame decorative appliances shall be installed in accordance with Section 932.1.1 through Section 932.1.3. [NFPA 54:10.31]

932.1.1 Listed Units. Listed outdoor open flame decorative appliances shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.31.1]

932.1.2 Unlisted Units. Unlisted outdoor open flame decorative appliances shall be installed outdoors in accordance with the manufacturer’s installation instructions and with clearances to combustible material of not less than 36 inches (914 mm) from the sides. In no case shall the appliance be located under overhead combustible construction. [NFPA 54:10.31.2]

932.1.3 Connection to the Piping System. The connection to the gas piping system shall be in accordance with Section 1312.1(1), Section 1312.1(2), Section 1312.1(4), or Section 1312.1(5). [NFPA 54:10.31.3]

933.0 Evaporative Cooling Systems.

933.1 General. Evaporative cooling systems, including air ducts and fire dampers that are a portion of an evaporative cooling system, shall be in accordance with Section 933.2 through Section 933.4.3. Evaporative cooling systems shall be provided with outside air as specified for cooling systems in Section 403.0.

933.2 Location. Evaporative cooling systems shall be installed so as to minimize the probability of damage from an external source.

933.3 Access, Inspection, and Repair. Evaporative coolers shall be accessible for inspection, service, and replacement without removing permanent construction.

933.4 Installation. An evaporative cooler supported by the building structure shall be installed on a level base and shall be secured directly or indirectly to the building structure, to prevent displacement of the cooler.

933.4.1 Modifications to the Supporting Structure. Modifications made to the supporting framework of buildings as a result of the installation shall be in accordance with the requirements of the building code. Openings in exterior walls shall be flashed in an approved manner in accordance with the requirements of the building code.

933.4.2 On the Ground. An evaporative cooler supported directly by the ground shall be isolated from the ground by a level concrete slab extending not less than 3 inches (76 mm) above the adjoining ground level.
933.4.3 **On a Platform.** An evaporative cooler supported on an aboveground platform shall be elevated not less than 6 inches (152 mm) above adjoining ground level.

934.0 Refrigeration Appliances.

934.1 **Self-Contained Refrigerators and Freezers.**
Factory-built commercial refrigerators and freezers shall comply with UL 471 or UL 60335-2-89 and shall be installed in accordance with the manufacturer’s installation instructions.

934.2 **Unit Coolers.**
Factory-built unit coolers for use in refrigerators, freezers, refrigerated warehouses, and walk-in coolers shall comply with UL 412 or UL 60335-2-89 and shall be installed in accordance with the manufacturer’s installation instructions.

934.3 **Self-Contained Mechanical Refrigeration Systems.**
Self-contained mechanical refrigeration systems for use in walk-in coolers shall comply with UL 427 or UL 60335-2-89 and shall be installed in accordance with the manufacturer’s installation instructions.

935.0 **Ductless Mini-Split Systems Installation.**

935.1 **General.** A ductless mini-split system installation shall be installed in accordance with the manufacturer’s installation instructions and Section 310.2 for condensate control.

936.0 **Air Filter Appliances.**

936.1 **Electrostatic Air Cleaners.**
Electrostatic air cleaners shall comply with UL 867 and installed in accordance with the manufacturer’s installation instructions.

936.2 **High-Efficiency Particulate Air Filter Units.**
High-efficiency particulate air filter units for use in industrial and laboratory exhaust and ventilation systems shall be installed in accordance with the manufacturer’s installation instructions.

937.0 **Gaseous Hydrogen Systems.**

937.1 **General.** Gaseous hydrogen systems shall be installed in accordance with NFPA 2.

938.0 **Compressed Natural Gas (CNG) Vehicular Fuel Systems.**

938.1 **General.** The installation of compressed natural gas (CNG) fueling (dispensing) systems shall conform to NFPA 52. Residential CNG fueling appliances shall be listed in accordance with CSA NGV 5.1 and installed in accordance to the appliance manufacturer’s installation instructions. [NFPA 54:10.28]
CHAPTER 10
BOILERS AND PRESSURE VESSELS

1001.0 General.
1001.1 Applicability. The requirements of this chapter shall apply to the construction, installation, operation, repair, and alteration of boilers and pressure vessels. Low-pressure boilers shall comply with this chapter and Section 904.0.

Exceptions:
(1) Listed and approved potable water heaters with a nominal capacity not exceeding 120 gallons (454 L) and having a heat input not exceeding 200 000 British thermal units per hour (Btu/h) (58.6 kW) used for hot water supply at a pressure not exceeding 160 pounds-force per square inch (psi) (1103 kPa) and at temperatures not exceeding 210°F (99°C), in accordance with the plumbing code.
(2) Pressure vessels used for unheated water supply, including those containing air that serves as a cushion and is compressed by the introduction of water and tanks connected to sprinkler systems.
(3) Portable unfired pressure vessels and Interstate Commerce Commission (I.C.C.) containers.
(4) Containers for liquefied petroleum gases, bulk oxygen, and medical gas that are regulated by the fire code.
(5) Unfired pressure vessels in business, factory, hazardous, mercantile, residential, storage, and utility occupancies having a volume not exceeding 5 cubic feet (0.14 m³) and operating at pressures not exceeding 250 psi (1724 kPa).
(6) Pressure vessels used in refrigeration systems shall comply with Chapter 11.
(7) Pressure tanks used in conjunction with coaxial cables, telephone cables, power cables, and other similar humidity control systems.
(8) A boiler or pressure vessel subject to regular inspection by federal inspectors or licensed by federal authorities.

1001.2 Boiler Rooms and Enclosures. Boiler rooms and enclosures shall comply with the building code.

1001.3 Air for Combustion and Ventilation. Air for combustion and ventilation shall be provided in accordance with Chapter 7.

1001.4 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.

1001.5 Mounting. Equipment shall be set or mounted on a level base capable of supporting and distributing the weight contained thereon. Boilers, tanks, and equipment shall be securely anchored to the structure. Equipment requiring vibration isolation shall be installed as designed by a registered design professional and approved by the Authority Having Jurisdiction.

1001.5.1 Floors. Boilers shall be mounted on floors of noncombustible construction unless listed for mounting on combustible flooring.

1001.6 Chimneys or Vents. Boilers shall be connected to a chimney or vent, as provided for other fuel-burning equipment in Chapter 8 of this code.

1002.0 Standards.
1002.1 General. Pressure vessels shall be constructed and designed in accordance with the ASME Boiler & Pressure Vessel Code (BPVC) Section VIII. Boilers shall be constructed, designed, and installed in accordance with one of the following:
(1) ASME BPVC Section I
(2) ASME BPVC Section IV
(3) NFPA 85

1002.2 Oil-Burning Boilers. Oil-burning boilers shall comply with Section 1002.2.1 and Section 1002.2.2.

1002.2.1 Listing & Labeling. Oil-burning boilers shall be listed and labeled in accordance with UL 726.

1002.2.2 Installation. Tanks, piping, and valves for oil-burning boilers shall be installed in accordance with NFPA 31.

1002.3 Electric Boilers. Electric boilers shall be listed and labeled in accordance with UL 834.

1002.4 Solid-Fuel-Fired Boilers. Solid-fuel-fired boilers shall comply with UL 2523 and shall be installed in accordance with the manufacturer’s installation instructions.

1002.5 Dual Purpose Water Heater. Water heaters utilized for combined space- and water-heating applications shall be listed or labeled in accordance with the standards referenced in Table 1203.2, and shall be installed in accordance with the manufacturer’s installation instructions.

1003.0 Detailed Requirements.
1003.1 Safety Requirements. The construction of boilers and pressure vessels and the installation thereof shall be in accordance with minimum requirements for safety from structural and mechanical failure and excessive pressures as established by the Authority Having Jurisdiction in accordance with nationally recognized standards.
1003.2 Controls. Required electrical, mechanical, safety, and operating controls shall carry the approval of an approved testing agency or be accepted by the Authority Having Jurisdiction. Electrical controls shall be of such design and construction as to be suitable for installation in the environment in which they are located.

1003.2.1 Automatic Boilers. Automatic boilers shall be equipped with controls and limit devices in accordance with ASME CSD-1 or Table 1003.2.1. The Authority Having Jurisdiction shall have the authority to approve solid-fuel-fired boilers that comply with the safety requirements for automatic gas fired boilers or oil fired boilers.

1003.3 Gauges. Steam boilers shall be provided with a pressure gauge and a water level glass. Water boilers shall be provided with a pressure gauge and a temperature gauge. Automatic boilers shall be equipped with the following gauges, as applicable:
1. Oil temperature
2. Oil suction pressure
3. High and low gas pressure
4. Stack temperature
5. Windbox pressure

1003.4 Stack Dampers. Stack dampers on boilers fired with oil or solid fuel shall not close off more than 80 percent of the stack area where closed, except on automatic boilers with prepurge, automatic draft control, and interlock. Operative dampers shall not be placed within a stack, flue, or vent of a gas-fired boiler, except on an automatic boiler with prepurge, automatic draft control, and interlock.

1003.5 Welding. Welding on pressure vessels shall be done by certified welders in accordance with nationally recognized standards.

1004.0 Expansion Tanks.

1004.1 General. An expansion tank shall be installed in a hot-water-heating system as a means for controlling increased pressure caused by thermal expansion. Expansion tanks shall be of the closed or open 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 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.

1004.2 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 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.

1004.3 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. Provisions shall be made for draining the tank without emptying the system.

1004.4 Minimum Capacity of Closed-Type Tank. The minimum capacity for a gravity-type hot water system expansion tank shall be in accordance with Table 1004.4(1). The minimum capacity for a forced-type hot water system expansion tank shall be in accordance with Table 1004.4(2), or Equation 1004.4. Equation 1004.4 shall not be used for diaphragm-type expansion tanks.

\[
V_t = \frac{(0.00041t - 0.0466) V_s}{\left(\frac{P_a}{P_f} - \frac{P_f}{P_o}\right)}
\]

(Equation 1004.4)

Where:

\(V_t\) = Minimum volume of expansion tank, gallons
\(V_s\) = Volume of system, not including expansion tank, gallons
\(t\) = Average operating temperature, °F
\(P_a\) = Atmospheric pressure, feet H2O absolute
\(P_f\) = Fill pressure, feet H2O absolute
\(P_o\) = Maximum operating pressure, feet H2O absolute

For SI units: 1 gallon = 3.785 L, °C = (°F-32)/1.8, 1 foot of water = 2.99 kPa

TABLE 1004.4(1)

<table>
<thead>
<tr>
<th>INSTALLED EQUIVALENT DIRECT RADIATION²</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>
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<td>Up to 900</td>
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<td>2 to 30</td>
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<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 that exceed 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.

Notes:
For SI units: 1 gallon = 3.785 L, 1 square foot = 0.0929 m²

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 that exceed 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.
1005.0 Safety or Relief Valve Discharge.

1005.1 General. Pressurized vessels or boilers shall be provided with overpressure protection by means of a listed pressure relief valve installed in accordance with the manufacturer’s installation instructions.

1005.2 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 provided with the following:

(1) Equal to 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.

(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.

1005.3 Splash Shield. Where the operating temperature exceeds 212°F (100°C), the discharge pipe shall be installed with a splash shield or centrifugal separator.

1005.4 Hazardous Discharge. Where the discharge from safety valves is capable of being hazardous, discharge of steam inside the boiler room, such discharge shall be dis- charged to the outside of the boiler room. Discharges from relief valves on industrial boilers shall be discharged to an approved location.

1005.5 Vacuum Relief Valve. Hot-water heating systems that are subjected to a vacuum while in operation or during shutdown shall be protected with a vacuum relief valve. Where the piping configuration, equipment location, and valve outlets are located below the boiler elevation, the system shall be equipped with a vacuum relief valve at the highest point.

1006.0 Shutoff Valves.

1006.1 General. An approved manual shutoff valve shall be installed upstream of all control devices on the main burner of a gas-fired boiler. The takeoff point for the gas supply to the pilot shall be upstream of the gas shutoff valve of the main burner and shall be valved separately. A union or other approved means of disconnect shall be provided immediately downstream of these shutoff valves.

1007.0 Gas-Pressure Regulators.

1007.1 General. An approved gas-pressure regulator shall be installed on gas-fired boilers where the gas supply pressure is exceeding that at which the main burner is designed to operate. A separate approved gas-pressure regulator shall be installed to regulate the gas pressure to the pilot or pilots.

1008.0 Low-Water Cutoff.

1008.1 General. Hot water boilers and steam boilers shall be installed with a low-water cutoff. A coil-type boiler or a water-tube boiler that requires forced circulation to prevent overheating of the coils or tubes shall be installed with a flow-sensing device in the outlet piping in lieu of the low-water cutoff. The low-water cutoff or the flow sensing device shall be installed so as to prevent damage to the boiler and to permit testing of the fuel-supply cutoff without draining the heating system. The low-water cutoff shall shut off the combustion at a water level setpoint that is in accordance with the boiler manufacturer’s instructions.

1009.0 Combustion Regulators – Safety Valves.

1009.1 General. The following requirements shall be retroactive:

(1) Hot-water-heating boilers, other than manually fired, shall be equipped with two temperature combustion regulators in series. Steam-heating boilers, other than manually fired, shall be equipped with a pressure combustion regulator and a low-water cutoff. (See Section 1008.0)

(2) Boilers and pressure vessels shall be provided with the required number, size, and capacity of safety or relief valves to ensure positive relief of overpressure in accordance with nationally recognized standards, as applicable. Valves so employed shall be constructed, sealed, and installed in accordance with nationally recognized standards, as applicable.
1010.0 Clearance for Access.

1010.1 General. Where boilers are installed or replaced, clearance shall be provided to allow access for inspection, maintenance, and repair. Passageways around all sides of boilers shall have an unobstructed width of not less than 18 inches (457 mm). Clearance for repair and cleaning shall be permitted to be provided through a door or access panel into another area, provided the opening is of sufficient size.

Exception: Subject to the approval of the Authority Having Jurisdiction, boilers shall be permitted to be installed with a side clearance of less than 18 inches (457 mm), provided that the lesser clearance does not inhibit inspection, maintenance, or repair.

1010.2 Power Boilers. Power boilers having a steam-generating capacity in excess of 5000 pounds per hour (lb/h) (0.6299 kg/s) or having a heating surface in excess of 1000 square feet (92.9 m²) or input in excess of 5 000 000 Btu/h (1464 kW) shall have a clearance of not less than 7 feet (2134 mm) from the top of the boiler to the ceiling.

1010.3 Steam-Heating Boilers, Hot Water Boilers, and Power Boilers. Steam-heating boilers and hot-water-heating boilers that exceed one of the following limits:

1. 5 000 000 Btu/h input (1464 kW)
2. 5000 pounds steam per hour (0.6299 kg/s) capacity
3. 1000 square foot (92.9 m²) heating surface

Power boilers that do not exceed one of the following limits:

1. 5 000 000 Btu/h input (1464 kW)
2. 5000 pounds steam per hour (0.6299 kg/s) capacity
3. 1000 square foot (92.9 m²) heating surface

Boilers with manholes on top of the boiler, except those described in Section 1010.2 and Section 1010.4, shall have a clearance of not less than 3 feet (914 mm) from the top of the boiler to the ceiling.

1010.4 Package Boilers, Steam-Heating Boilers, and Hot-Water-Heating Boilers. Package boilers, steam-heating boilers, and hot-water-heating boilers with no manhole on top of the shell and not exceeding one of the above limits shall have a clearance of not less than 2 feet (610 mm) from the ceiling.

1011.0 Boilers, Stokers, and Steam Generators.

1011.1 General. The design, installation, and operation of single burner boilers, multiple burner boilers, stokers, and atmospheric fluidized-bed boilers with not less than a fuel input rating of 12.5 E+06 Btu/h (3.663 MW) to pulverized fuel systems, fired or unfired steam generators used to recover heat from combustion turbines and to other combustion turbine exhaust systems shall be in accordance with NFPA 85. That portion of the oil-burning system supplied on boilers and covered within the scope of NFPA 85 shall be installed in accordance with NFPA 85.

1012.0 Operating Adjustments and Instructions.

1012.1 General. Hot water boiler installations, upon completion, shall have controls set, adjusted, and tested by the installing contractor. A complete control diagram of a permanent legible type, together with complete boiler operating instructions, shall be furnished by the installer for each installation.

1013.0 Inspections and Tests.

1013.1 General. An installation for which a permit is required shall not be put into service until it has been inspected and approved by the Authority Having Jurisdiction.

It shall be the duty of the owner or his authorized representative to notify the Authority Having Jurisdiction that the installation is ready for inspection and test. It also shall be the duty of the owner or his authorized representative to post in a conspicuous position on the installation a notice in substantially the following form: “Warning! This installation has not been inspected and approved by the Authority Having Jurisdiction and shall not be covered or concealed until so inspected and approved,” and it shall be unlawful for anyone other than the Authority Having Jurisdiction to remove such notice. The Authority Having Jurisdiction shall require such tests as it deems necessary to determine that the installation is in accordance with the provision of this section. Such tests shall be made by the owner or his authorized representative in the presence of the Authority Having Jurisdiction.

Exception: On installations designed and supervised by a registered design professional, the Authority Having Jurisdiction shall have the authority to permit inspection and testing by such registered design professional.

Where the owner or his authorized representative requests inspection of a boiler prior to its installation, the Authority Having Jurisdiction shall make such inspection.

1013.2 Operating Permit. It shall be unlawful to operate a boiler or pressure vessel without first obtaining a valid operating permit to do so from the Authority Having Jurisdiction. Such permit shall be displayed in a conspicuous place adjacent to the boiler or vessel. The operating permit shall not be issued until the equipment has been inspected and approved by the Authority Having Jurisdiction.

Exception: The operation of steam-heating boilers, low-pressure hot-water-heating boilers, hot water supply boilers, and pressure vessels in residential occupancies of less than six dwelling units and utility occupancies.

1013.3 Maintenance Inspection. The Authority Having Jurisdiction shall inspect boilers and pressure vessels operated under a permit in accordance with ASHRAE/ACCA 180 at such intervals as deemed necessary, but not less frequently than in accordance with Section 1013.4 through Section 1013.7.

1013.4 Power and Miniature Boilers. Power boilers and miniature boilers shall be inspected externally annually. Where construction and operating conditions permit, they shall be subject to inspection internally annually.
1013.5 *Steam-Heating and Water-Heating Boilers.* Steam-heating boilers and hot-water-heating boilers shall be inspected externally annually. Where construction and operating conditions permit, they shall also be subject to inspection internally annually.

1013.6 *Automatic Steam-Heating Boilers.* Automatic steam-heating boilers shall be inspected externally biennially. Where construction and operating conditions permit, they shall be subject to inspection internally biennially.

1013.7 *Unfired Pressure Vessels.* Unfired pressure vessels shall be inspected externally biennially. Where subject to corrosion and construction permits, they shall be subject to inspection internally biennially.

Inspection of boilers and pressure vessels covered by insurance shall be permitted to be made by employees of the insuring company holding commissions from the National Board of Boiler and Pressure Vessel Inspectors, subject to approval of the Authority Having Jurisdiction. Approved insuring company inspectors shall make reports on prescribed forms on inspections authorized by the Authority Having Jurisdiction. The reports shall be filed in the Authority Having Jurisdiction office. Company inspectors shall notify the Authority Having Jurisdiction of suspension of insurance because of dangerous conditions, new insurance in effect, and discontinuance of insurance coverage.

1014.0 *Operation and Maintenance of Boilers and Pressure Vessels.*

1014.1 *General.* Boilers and pressure vessels shall be operated and maintained in accordance with requirements for protection of the public established by the Authority Having Jurisdiction in accordance with nationally recognized standards.

The Authority Having Jurisdiction shall notify the owner or authorized representative of defects or deficiencies and properly corrected. Where such corrections are not made, or where the operation of the boiler or pressure vessel is deemed unsafe by the Authority Having Jurisdiction, they shall have the authority to revoke the permit to operate the boiler or pressure vessel. Where the operation of a boiler or pressure vessel is deemed by the Authority Having Jurisdiction to constitute an immediate danger, the pressure on such boiler or pressure vessel shall be permitted to be relieved at the owner’s cost and the boiler or pressure vessel shall not thereafter be operated without the approval of the Authority Having Jurisdiction.
<table>
<thead>
<tr>
<th>BOILER GROUP</th>
<th>FUEL</th>
<th>FUEL INPUT RANGE (INCLUSIVE), BTU/H</th>
<th>TYPE OF PILOT</th>
<th>TRIAL FOR PILOT</th>
<th>DIRECT ELECTRIC IGNITION</th>
<th>FLAME PILOT</th>
<th>MAIN BURNER FLAME FAILURE</th>
<th>ASSURED FUEL SUPPLY CONTROL</th>
<th>ASSURED AIR SUPPLY CONTROL</th>
<th>LOW FIRE START UP CONTROL</th>
<th>PRE-PURGING CONTROL</th>
<th>HOT WATER TEMPERATURE AND LOW WATER LIMIT CONTROLS</th>
<th>STEAM PRESSURE AND LOW WATER LIMIT CONTROLS</th>
<th>APPROVED FUEL SHUT-OFF</th>
<th>CONTROL AND LIMIT DEVICE SYSTEM DESIGN</th>
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</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW
FOOTNOTES FOR TABLE 1003.2.1 (continued)

1 Fuel input shall be determined by one of the following:
The burner input shall not exceed the input shown on the burner nameplate or as otherwise identified by the manufacturer.
The nominal boiler rating, as determined by the building official, plus 25 percent.

2 Automatic boilers shall have one flame failure device on each burner, which shall prove the presence of an ignition source at the point where it will ignite the main burner, except that boiler groups A, B, E, F, and G, which are equipped with direct electric ignition, shall monitor the main burner, and boiler groups using interrupted pilots shall monitor the main burner after the prescribed limited trial and ignition periods. Boiler group A, equipped with continuous pilot, shall accomplish 100 percent shutdown within 90 seconds upon pilot flame failure. The use of intermittent pilots in boiler group C is limited to approved burner units.

3 In boiler groups B, C, and D a 90 second main burner flame failure limit shall be permitted to be applied where continuous pilots are provided on manufacturer assembled boiler-burner units that have been approved by an approved testing agency in accordance with nationally recognized standards approved by the building official. Boiler groups F and G equipped to re-energize their ignition systems within 0.8 second after main burner flame failure will be permitted 30 seconds for group F or 15 seconds for group G to re-establish their main burner flames.

4 Boiler groups C and D shall have controls interlocked to accomplish a non-recycling fuel shutoff upon high or low gas pressure, and boiler groups F, G, and H using steam or air for fuel atomization shall have controls interlocked to accomplish a nonrecycling fuel shutoff upon low atomizing steam or air pressure. Boiler groups F, G, and H equipped with a preheated oil system shall have controls interlocked to provide fuel shutoff upon low oil temperature.

5 Automatic boilers shall have controls interlocked to shut off the fuel supply in the event of draft failure where forced or induced draft fans are used or, in the event of low combustion airflow, where a gas power burner is used. Where a single motor directly driving both the fan and the oil pump is used, a separate control is not required.

6 Boiler groups C, D, and H, where firing in excess of 400 000 Btu/h (117 kW) per combustion chamber, shall be provided with low fire start of its main burner system to permit smooth light-off. This will normally be a rate of one-third of its maximum firing rate.

7 Boiler groups C, D, and H shall not permit pilot or main burner trial for ignition operation before a purging operation of sufficient duration to permit not less than four complete air changes through the furnace, including a combustion chamber and the boiler passes. Where this is not readily determinable, five complete air changes of the furnace, including combustion chamber up to the first pass, will be considered equivalent. An atmospheric gas burner with no mechanical means of creating air movement or an oil burner that obtains two-thirds or more of the air required for combustion without mechanical means of creating air movement shall not require purge by means of air changes, so long as its secondary air openings are not provided with means of closing. Where such burners have means of closing secondary air openings, a time delay shall be provided that puts these closures in a normally open position for four minutes before an attempt for ignition. An installation with a trapped combustion chamber shall, in every case, be provided with a mechanical means of creating air movement for purging.

8 An automatic hot-water-heating boiler, low-pressure hot-water-heating boiler, and power hot water boiler shall be equipped with two high-temperature limit controls with a manual reset on the control, with the higher setting interlocked to shut off the main fuel supply, except that manual reset on the high-temperature limit control shall not be required on an automatic package boiler not exceeding 400 000 Btu/h (117 kW) input and that has been approved by an approved testing agency. An automatic hot-water heating, power boiler, and package hot-water supply boiler shall be equipped with one low-water level limit control with a manual reset interlocked to shut off the fuel supply, so installed as to prevent damage to the boiler and to permit testing of the control without draining the heating system, except on boilers used in Group R Occupancies of less than six units and in Group U Occupancies and further, except that the low-water level limit control is not required on package hot-water supply boilers approved by a nationally recognized testing agency. However, a low-water flow limit control installed in the circulating water line shall be permitted to be used instead of the low-water level limit control for the same purpose on coil-type boilers.

9 An automatic low-pressure steam-heating boiler, small power boiler, and power steam boiler shall be equipped with two high-steam pressure limit controls interlocked to shut off the fuel supply to the main burner with manual reset on the control, with the higher setting and two low-water level limit controls, one of which shall be provided with a manual reset device and independent of the feed water controller. Coil-type flash steam boilers shall be permitted to use two high-temperature limit controls, one of which shall be manually reset in the hot water coil section of the boiler instead of the low-water level limit control.

10 Boiler groups C, D, and H shall use an approved automatic reset safety shutoff valve for the main burner fuel shutoff, which shall be interlocked to the programming control devices required. On oil burners where the safety shutoff valve will be subjected to pressures in excess of 10 psi (69 kPa) where the burner is not firing, a second safety shutoff valve shall be provided in series with the first. Boiler groups C and D using gas in excess of 1 psi (7 kPa) pressure or having a trapped combustion chamber or employing horizontal fire tubes shall be equipped with two approved safety shutoff valves, one of which shall be an automatic reset type, one of which shall be permitted to be used as an operating control, and both of which shall be interlocked to the limit-control devices required. Boiler groups C and D using gas in excess of 1 psi (7 kPa) pressure shall be provided with a permanent and ready means for making periodic tightness checks of the main fuel safety shutoff valves.

11 Control and limit device systems shall be grounded with operating voltage not to exceed 150 volts, except that, upon approval by the building official, existing control equipment to be reused in an altered boiler control system shall be permitted to use 220 volts single phase with one side grounded, provided such voltage is used for all controls. Control and limit devices shall interrupt the ungrounded side of the circuit. A readily accessible means of manually disconnecting the control circuit shall be provided with controls so arranged that where they are de-energized, the burner shall be inoperative.
CHAPTER 11
REFRIGERATION

1101.0 General.
1101.1 Applicability. Part I governs the design, installation, and construction of refrigeration systems, equipment, refrigerant piping, pressure vessels, safety devices, replacement of parts, alterations, and substitution of different refrigerants. Part II governs the installation and construction of cooling towers.

1101.2 Equipment. Equipment for refrigerant recovery, recycling, or both shall comply with UL 1963.


1102.0 Refrigeration Systems.
1102.1 General. Refrigeration systems using a refrigerant other than ammonia shall comply with this chapter and ASHRAE 15.

1102.2 Ammonia Refrigeration Systems. Refrigeration systems using ammonia as the refrigerant shall comply with IIAR 2, IIAR 3, IIAR 4, and IIAR 5 and shall not be required to comply with this chapter.

1102.3 Refrigerants. The refrigerant used shall be of a type listed in Table 1102.3 or in accordance with ASHRAE 34 where approved by the Authority Having Jurisdiction.

Exception: Lithium bromide absorption systems using water as the refrigerant.

1103.0 Classification.
1103.1 Classification of Refrigerants. Refrigerants shall be classified in accordance with Table 1102.3 or in accordance with ASHRAE 34 where approved by the Authority Having Jurisdiction.

1103.1.1 Safety Group. Table 1102.3 classifies refrigerants by toxicity and flammability, and assigns safety groups using combinations of toxicity class and flammability class. For the purposes of this chapter, the refrigerant Groups A1, A2L, A2, A3, B1, B2L, B2, and B3 shall be considered to be individual and distinct safety groups. Each refrigerant is assigned into not more than one group.

1103.2 Classification of Refrigeration Systems. Refrigeration systems shall be classified according to the degree of probability that a leakage of refrigerant will enter an occupancy-classified area in accordance with Section 1103.2.1 and Section 1103.2.2. [ASHRAE 15:5.2]

1103.2.1 High-Probability System. Systems in which the basic design, or the location of components, is such that a leakage of refrigerant from a failed connection, seal, or component will enter the occupied space shall be classified as high-probability systems. A high-probability system shall be a direct system or an indirect open spray system in which the refrigerant is capable of producing pressure that is more than the secondary coolant. [ASHRAE 15:5.2.1]

1103.2.2 Low-Probability System. Systems in which the basic design, or the location of the components, is such that a leakage of refrigerant from a failed connection, seal, or component is not capable of entering the occupied space shall be classified as low-probability systems. A low-probability system shall be an indirect closed system, double indirect system, or an indirect open spray system. In a low-probability indirect open spray system, the secondary coolant pressure remains more than the refrigerant pressure in operating and standby conditions. [ASHRAE 15:5.2.2]

1103.3 Higher Flammability Refrigerants. Group A3 and B3 refrigerants shall not be used except where approved by the Authority Having Jurisdiction.

Exceptions:
(1) Laboratories with more than 100 square feet (9.29 m²) of space per person.
(2) Industrial occupancies.
(3) Listed portable unit self-contained systems containing not more than 0.331 pounds (0.150 kg) of Group A3 refrigerant, provided that the equipment is installed in accordance with the listing and the manufacturer’s installation instructions. [ASHRAE 15:7.5.3]

1104.0 Requirements for Refrigerant and Refrigeration System Use.
1104.1 System Selection. Refrigeration systems shall be limited in application in accordance with Table 1104.1, and the requirements of Section 1104.0.

1104.2 Refrigerant Concentration Limit. The concentration of refrigerant in a complete discharge of an independent circuit of high-probability systems shall not exceed the amounts shown in Table 1102.3, except as provided in Section 1104.3 and Section 1104.4. The volume of occupied space shall be determined in accordance with Section 1104.2.1 through Section 1104.2.3.

Exceptions:
(1) Listed equipment containing not more than 6.6 pounds (2.99 kg) of refrigerant, regardless of the refrigerant safety classification, provided the equipment is installed in accordance with the listing and with the manufacturer’s installation instructions.
(2) Listed equipment for use in laboratories with more than 100 square feet (9.29 m²) of space per person, regardless of the refrigerant safety classification, provided that the equipment is installed in accordance with the listing and the manufacturer’s installation instructions. [ASHRAE 15:7.2]
1104.2.1 Volume Calculations. The volume used to convert from refrigerant concentration limits to refrigerating system quantity limits for refrigerants in Section 1104.2 shall be based on the volume of space to which refrigerant disperses in the event of a refrigerant leak. [ASHRAE 15:7.3.1]

1104.2.2 Nonconnecting Spaces. Where a refrigerating system or part thereof is located in one or more enclosed occupied spaces that do not connect through permanent openings or HVAC ducts, the volume of the smallest occupied space shall be used to determine the refrigerant quantity limit in the system. Where different stories and floor levels connect through an open atrium or mezzanine arrangement, the volume to be used in calculating the refrigerant quantity limit shall be determined by multiplying the floor area of the lowest space by 8.2 feet (2499 mm). [ASHRAE 15:7.3.1]

1104.2.3 Ventilated Spaces. Where a refrigerating system or part thereof is located within an air handler, in an air distribution duct system, or in an occupied space served by a mechanical ventilation system, the entire air distribution system shall be analyzed to determine the worst-case distribution of leaked refrigerant. The worst case or the smallest volume in which the leaked refrigerant disperses shall be used to determine the refrigerant quantity limit in the system. Where different stories and floor levels connect through an open atrium or mezzanine arrangement, the volume to be used in calculating the refrigerant quantity limit shall be determined by multiplying the floor area of the lowest space by 8.2 feet (2499 mm). [ASHRAE 15:7.3.1 through Section 1104.2.3.3. [ASHRAE 15:7.3.2]]

1104.2.3.1 Closures. Closures in the air distribution system shall be considered. Where one or more spaces of several arranged in parallel are capable of being closed off from the source of the refrigerant leak, their volume(s) shall not be used in the calculation.

Exceptions: The following closure devices shall not be considered:

(1) Smoke dampers, fire dampers, and combination smoke and fire dampers that close only in an emergency not associated with a refrigerant leak.

(2) Dampers, such as variable-air-volume (VAV) boxes, that provide limited closure where airflow is not reduced below 10 percent of its maximum (with the fan running). [ASHRAE 15:7.3.2.1]

1104.2.3.2 Plenums. The space above a suspended ceiling shall not be included in calculating the refrigerating system quantity limits in the system unless such space is part of the air supply or return system. [ASHRAE 15:7.3.2.2]

1104.2.3.3 Supply and Return Ducts. The volume of the supply and return ducts and plenums shall be included when calculating the refrigerating system quantity limits in the system. [ASHRAE 15:7.3.2.3]

1104.3 Institutional Occupancies. The RCL value required in Section 1104.2 shall be reduced by 50 percent for the areas of institutional occupancies. The total of Group A2, B2, A3, and B3 refrigerants shall not exceed 550 pounds (249.5 kg) in the occupied areas and machinery rooms of institutional occupancies.

Exception: The total of all Group A2L refrigerants shall not be limited in machinery rooms of institutional occupancies.

1104.4 Industrial Occupancies and Refrigerated Rooms. Section 1104.2 shall not apply in industrial occupancies and refrigerated rooms where in accordance with the following:

(1) The space(s) containing the machinery is (are) separated from other occupancies by tight construction with tight-fitting doors.

(2) Access is restricted to authorized personnel.

(3) The floor area per occupant is not less than 100 square feet (9.29 m²).

Exceptions: The minimum floor area shall not apply where the space is provided with egress directly to the outdoors or into approved building exits.

(4) Refrigerant detectors are installed with the sensing location and alarm level as required in refrigeration machinery rooms in accordance with Section 1104.2.3.

(5) Open flames and surfaces exceeding 800°F (427°C) shall not be permitted where a Group A2, B2, A3, or B3 refrigerant, is used.

(6) Electrical equipment that is in accordance with Class 1, Division 2, of NFPA 70 where the quantity of a Group A2, B2, A3, or B3 refrigerant in an independent circuit is capable of exceeding 25 percent of the lower flammability limit (LFL) upon release to the space based on the volume determined in accordance with Section 1104.2.1 through Section 1104.2.3.

(7) Refrigerant containing parts in systems exceeding 100 horsepower (74.6 kW) compressor drive power, except evaporators used for refrigeration or dehumidification, condensers used for heating, control and pressure-relief valves for either, low-probability pumps, and connecting piping, are located in a machinery room or outdoors. [ASHRAE 15:7.2.2]

1104.5 Flammable Refrigerants. The total of Group A2, B2, A3, and B3 refrigerants, other than Group A2L and B2L refrigerants shall not exceed 1100 pounds (498.9 kg) without approval by the Authority Having Jurisdiction. Institutional Occupancies shall comply with Section 1104.3.

1104.6 Applications for Human Comfort and for Nonindustrial Occupancies. In nonindustrial occupancies, Group A2, A2L, A3, B1, B2L, B2, and B3 refrigerants shall not be used in high-probability systems for human comfort.

1104.7 Refrigerant Type and Purity. Refrigerants shall be of a type specified by the equipment manufacturer. Unless otherwise specified by the equipment manufacturer, refriger-
shall be selected or other approved methods. contamination shall be evaluated for suitability. [ASHRAE 15:5.3]

**1105.1 Human Comfort.** Cooling systems used for human comfort shall be in accordance with the return-air and outside-air provisions for furnaces in Section 904.7 and Section 904.8. Cooling equipment used for human comfort in dwelling units and residential buildings shall be selected in accordance with ACCA Manual S to satisfy the calculated loads determined in accordance with the reference standards in Chapter 17 ACCA Manual J or other approved methods. Refrigerants used for human comfort shall be in accordance with Section 1104.6.

**1105.2 Supports and Anchorage.** Supports and anchorage for refrigeration equipment and piping shall be designed in accordance with the building code as Occupancy Category H (hazardous facilities). Supports shall be made of noncombustible materials.

**Exceptions:**

(1) Refrigerant evaporators, suspended overhead, shall be permitted to use portable means of access.

(2) Refrigerant evaporators, suspended overhead, shall be permitted to be supported by the same materials permitted for the building type.

(3) The use of approved vibration isolators specifically designed for the normal, wind, and seismic loads encountered, shall be permitted.

A compressor or portion of a condensing unit supported from the ground shall rest on a concrete or other approved base extending not less than 3 inches (76 mm) above the adjoining ground level.

**1105.3 Access.** An unobstructed readily accessible opening and passageway not less than 36 inches (914 mm) in width and 80 inches (2032 mm) in height shall be provided and maintained to the compressor, valves required by this chapter, or other portions of the system requiring routine maintenance.

**Exceptions:**

(1) Refrigerant evaporators, suspended overhead, shall be permitted to be supported by the same materials permitted for the building type.

(2) Air filters, brine control or stop valves, fan motors or drives, and remotely de-energized electrical connections shall be permitted to be provided access to an unobstructed space not less than 30 inches (762 mm) in depth, width, and height. Where an access opening is immediately adjacent to these items and the equipment is capable of being serviced, repaired, and replaced from this opening, the dimensions shall be permitted to be reduced to 22 inches (559 mm) by 30 inches (762 mm) provided the largest piece of equipment is removed through the opening.

(3) Cooling equipment, using Group A1 refrigerants or brine, located in an attic or buried space shall be permitted to be provided access by a minimum opening and passageway thereto of not less than 22 inches (559 mm) by 30 inches (762 mm).

(4) Cooling or refrigeration equipment, using Group A1 or B1 refrigerants or brine, located on a roof or on an exterior wall of a building, shall be permitted to be provided access as for furnaces in Section 304.3.

**1105.4 Illumination and Service Receptacles.** In addition to the requirements of Section 301.4, permanent lighting fixtures shall be installed for equipment required by this code to be accessible or readily accessible. Such fixtures shall provide illumination to perform the required tasks for which access is provided. Control of the illumination source shall be provided at the access entrance.

**Exceptions:**

(1) Lighting fixtures shall be permitted to be omitted where the fixed lighting of the building will provide the required illumination.
1105.5 Ventilation of Rooms Containing Condensing Units. Where not in a refrigerant machinery room, rooms or spaces in which a refrigerant-containing portion of a condensing unit is installed shall be provided with ventilation in accordance with Section 1105.5.1 or Section 1105.5.2. Ventilation for machinery rooms shall comply with Section 1106.0.

1105.5.1 Permanent Gravity Ventilation Openings. Permanent gravity ventilation openings of not less than 2 square feet (0.2 m²) net free area opening shall be terminated directly to the outside of the building or extend to the outside of the building by continuous ducts.

1105.5.2 Mechanical Exhaust System. A mechanical exhaust system shall be designed to provide complete change of air not less than every 20 minutes in such room or space and shall discharge to the outside of the building.

Exceptions:

(1) A condensing unit in a room or space where the cubical content exceeds 1000 cubic feet per horsepower (ft³/hp) (37.95 m³/kW) of the unit.

(2) A condensing unit in a room or space that has permanent gravity ventilation having an area of 2 square feet (0.2 m²) or more to other rooms or openings exceeding 1000 ft³/hp (37.95 m³/kW).

1106.0 Refrigeration Machinery Rooms.

1106.1 Where Required. Refrigeration systems shall be provided with a refrigeration machinery room where the conditions as outlined in Section 1106.1.1 through Section 1106.1.4 exist.

Exception: Refrigeration equipment shall be permitted to be located outdoors in accordance with ASHRAE 15.

1106.1.1 Quantity. The quantity of refrigerant in a single, independent refrigerant circuit of a system exceeds the amounts of Table 1102.3.

1106.1.2 Equipment. Direct- and indirect-fired absorption equipment is used.

Exception: Direct and indirect-fired lithium bromide absorption systems using water as the refrigerant.

1106.1.3 A1 System. An A1 system having an aggregate combined compressor horsepower of 100 (74.6 kW) or more is used.

1106.1.4 A1 Refrigerant. The system contains other than a Group A1 refrigerant.

Exceptions:

(1) Lithium bromide absorption systems using water as the refrigerant.

(2) Systems containing less than 300 pounds (136.1 kg) of refrigerant R-123 and located in an approved exterior location.

Refrigeration machinery rooms shall house refrigerant-containing portions of the system other than the piping and evaporators permitted by Section 1104.4, discharge piping required of this chapter, and cooling towers regulated by Part II of this chapter, and their essential piping.

1106.2 Refrigeration Machinery Room, General Requirements. Where a refrigeration system is located indoors and a machinery room is required in accordance with Section 1106.1, the machinery room shall be in accordance with Section 1106.2.1 through Section 1106.2.5.2.

1106.2.1 Access. Machinery rooms shall not be prohibited from housing other mechanical equipment unless specifically prohibited elsewhere in this chapter. A machinery room shall be so dimensioned that parts are
1106.2.2 Openings. Each refrigeration machinery room shall have a tight-fitting door or doors opening outward, self-closing where they open into the building and adequate in number to ensure freedom for persons to escape in an emergency. With the exception of access doors and panels in air ducts and air-handling units in accordance with Section 1106.6, there shall be no openings that will permit passage of escaping refrigerant to other parts of the building. [ASHRAE 15: 8.11.2]

1106.2.2.1 Detectors and Alarms. Each refrigeration machinery room shall contain one or more refrigerant detectors in accordance with Section 1106.2.2.2, located in areas where refrigerant from a leak will concentrate, that actuate an alarm and mechanical ventilation in accordance with Section 1106.2.4 at a set point not more than the corresponding Occupational Exposure Limit, OEL, in accordance with Table 1102.3, a set point determined in accordance with the OEL as defined in Chapter 2 shall be approved by the Authority Having Jurisdiction. The alarm shall annunciate visual and audible alarms inside the refrigeration machinery room and outside each entrance to the refrigeration machinery room. The alarms required in this section shall be of the manual reset type with the reset located inside the refrigeration machinery room. Alarms set at other levels, such as IDLH, and automatic reset alarms shall be permitted in addition to those required in accordance with this section. The meaning of each alarm shall be clearly marked by signage near the annunciator.

Exception: Refrigerant detectors are not required where only systems using R-718 (water) are located in the refrigeration machinery room.

1106.2.2.2 Refrigerant Detectors. Refrigerant detectors required in accordance with Section 1106.2.2.1 or Section 1107.1.7 shall meet all of the following conditions:

1. The refrigerant detector shall perform automatic self-testing of sensors. Where a failure is detected, a trouble signal shall be activated.
2. The refrigerant detector shall have one or more set points to activate responses in accordance with Section 1106.2.2.1 or Section 1107.1.7.
3. The refrigerant detector as installed, including any sampling tubes, shall activate responses within a time not to exceed 30 seconds after exposure to refrigerant concentration exceeding the set point value specified in Section 1106.2.2.1 or Section 1107.1.7.

1106.2.3 Mechanical Ventilation. Machinery rooms shall be vented to the outdoors, utilizing mechanical ventilation in accordance with Section 1106.2.4 and Section 1106.2.5.

1106.2.4 Ventilation. Mechanical ventilation referred to in Section 1106.2.3 shall be by one or more power-driven fans capable of exhausting air from the machinery room at not less than the amount shown in accordance with Section 1106.2.5.

To obtain a reduced airflow for normal ventilation, multiple fans or multispeed fans shall be used. Provision shall be made to supply make-up air to replace that being exhausted. Ducts for supply and exhaust to the machinery room shall serve no other area. The makeup air supply locations shall be positioned relative to the exhaust air locations to avoid short-circuiting. Inlets to the exhaust ducts shall be located in an area where refrigerant from a leak will concentrate, in consideration of the location of the replacement supply air paths, refrigerating machines, and the density of the refrigerant relative to air.

Inlets to exhaust ducts shall be within 1 foot (305 mm) of the lowest point of the machinery room for refrigerants that are heavier than air, and shall be within 1 foot (305 mm) of the highest point for refrigerants that are lighter than air. The discharge of the exhaust air shall be to the outdoors in such a manner as not to cause a nuisance or danger.

1106.2.5 Emergency Ventilation-Required Airflow. An emergency ventilation system shall be required to exhaust an accumulation of refrigerant due to leaks or a rupture of the system. The emergency ventilation required shall be capable of removing air from the machinery room in not less than the airflow quantity in Section 1106.2.5.1 or Section 1106.2.5.2. Where multiple refrigerants are present, then the highest airflow quantity shall apply.

1106.2.5.1 Ventilation - A1, A2, A3, B1, B2L, B2 and B3 refrigerants. The emergency ventilation for A1, A2, A3, B1, B2L, B2 and B3 refrigerants shall have the capacity to provide mechanical exhaust at a rate as determined in accordance with Equation 1106.2.5.1:

\[ Q = 100 \sqrt{G} \]  

(Equation 1106.2.5.1)

Where:
- \( Q \) = Air flow rate, cubic feet per minute.
- \( G \) = Refrigerant mass in largest system, pounds.

For SI units: 1 cubic foot per minute = 0.00047 m\(^3\)/s, 1 pound = 0.453 kg

1106.2.5.2 Ventilation - Group A2L Refrigerants. The emergency ventilation for A2L refrigerants shall have the capacity to provide mechanical exhaust at a rate determined in accordance with Table 1106.2.5.2:
TABLE 1106.2.5.2
REQUIRED AIRFLOW FOR GROUP A2L REFRIGERANTS

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>MINIMUM AIR FLOW* (CFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R32</td>
<td>32,500</td>
</tr>
<tr>
<td>R143a</td>
<td>28,600</td>
</tr>
<tr>
<td>R444A</td>
<td>13,700</td>
</tr>
<tr>
<td>R444B</td>
<td>22,400</td>
</tr>
<tr>
<td>R445A</td>
<td>16,400</td>
</tr>
<tr>
<td>R446A</td>
<td>50,500</td>
</tr>
<tr>
<td>R447A</td>
<td>50,200</td>
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<tr>
<td>R447B</td>
<td>29,600</td>
</tr>
<tr>
<td>R451A</td>
<td>14,900</td>
</tr>
<tr>
<td>R451B</td>
<td>14,900</td>
</tr>
<tr>
<td>R452B</td>
<td>31,500</td>
</tr>
<tr>
<td>R454A</td>
<td>4290</td>
</tr>
<tr>
<td>R454B</td>
<td>6650</td>
</tr>
<tr>
<td>R454C</td>
<td>32,800</td>
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<tr>
<td>R455A</td>
<td>4770</td>
</tr>
<tr>
<td>R457A</td>
<td>31,400</td>
</tr>
<tr>
<td>R1234yf</td>
<td>16,500</td>
</tr>
<tr>
<td>R1234zeE</td>
<td>12,600</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s.

* The values were tabulated from the following equation:

\[ Q_{A2L} \geq \frac{(\rho \cdot v \cdot A)}{(LFL \cdot 0.50)} \]  

(Equation 1106.2.5.2)

Where:
\[ \rho = \text{Refrigerant density, pounds per cubic feet (kg/m}^3) \]
\[ v = \text{Refrigerant velocity equal to the refrigerant acoustic velocity (speed of sound), feet per second (m/s).} \]
\[ A = \text{Cross-section flow area of refrigerant leak, square feet (m}^2) \]
\[ LFL = \text{Lower Flammability Limit, or ETFL}_{60} \text{ or where no LFL exist, published value in accordance with ASHRAE 34.} \]
\[ Q_{A2L} = \text{Minimum required air flow rate, conversion to other units of measures is permitted, cubic feet per second (m}^3/s). \]

For exact ventilation rates and for refrigerants not listed, the ventilation rate shall be calculated using this equation.

1106.3 Normal Operation. A part of the refrigeration machinery room mechanical ventilation shall be in accordance with the following:

(1) Operated, where occupied, to supply not less than 0.5 cfm/ft² (2.54 L/s/m²) of machinery room area or 20 cubic feet per minute (9.44 L/s) per person.

(2) Operable, where occupied at a volume required to not exceed the higher of a temperature rise of 18°F (10°C) above inlet air temperature or a maximum temperature of 122°F (50°C).

1106.4 Natural Ventilation. Where a refrigerating system is located outdoors more than 20 feet (6096 mm) from buildings opening and is enclosed by a penthouse, lean-to, or other open structure, natural or mechanical ventilation shall be provided. The requirements for such natural ventilation shall be in accordance with the following:

(1) The free-aperture cross section for the ventilation of a machinery room shall be not less than as determined in accordance with Equation 1106.4.

\[ F = \sqrt{G} \]  

(Equation 1106.4)

Where:
\[ F = \text{The free opening area, square feet.} \]
\[ G = \text{The mass of refrigerant in the largest system, any part of which is located in the machinery room, pounds.} \]

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 pound = 0.453 kg

(2) The location of the gravity ventilation openings shall be based on the relative density of the refrigerant to air. [ASHRAE 15:8.11.5(a), (b)]

1106.5 Combustion Air. No open flames that use combustion air from the machinery room shall be installed where refrigerant is used. Combustion equipment shall not be installed in the same machinery room with refrigerant-containing equipment except under one of the following conditions:

(1) Combustion air shall be ducted from outside the machinery room and sealed in such a manner as to prevent refrigerant leakage from entering the combustion chamber.

(2) A refrigerant detector, that is in accordance with Section 1106.2.2.1, shall be installed to automatically shut down the combustion process in the event of refrigerant leakage.

Exception: Machinery rooms where carbon dioxide (R-744) or water (R-718) is the refrigerant.

1106.6 Airflow. There shall be no airflow to or from an occupied space through a machinery room unless the air is ducted and sealed in such a manner as to prevent refrigerant leakage from entering the airstream. Access doors and panels in ductwork and air-handling units shall be gasketed and tight fitting. [ASHRAE 15:8.11.7]

1106.7 Ventilation Intake. Makeup air intakes to replace the exhaust air shall be provided to the refrigeration machinery room directly from outside the building. Intakes shall be located as required by other sections of the code and fitted with backdraft dampers or other approved flow-control means to prevent reverse flow. Distribution of makeup air shall be arranged to provide thorough mixing within the refrigeration machinery room to prevent short circuiting of the makeup air directly to the exhaust.

1106.8 Maximum Temperature. Ventilation or mechanical cooling systems shall be provided to maintain a temperature of not more than 104°F (40°C) in the refrigerant machinery room under design load and weather conditions.
1106.9 Refrigerant Parts in Air Duct. Joints and refrigerant-containing parts of a refrigerating system located in an air duct carrying conditioned air to and from an occupied space shall be constructed to withstand a temperature of 700°F (371°C) without leakage into the airstream. [ASHRAE 15:8.8]

1106.10 Dimensions. Refrigeration machinery rooms shall be of such dimensions that system parts are readily accessible with approved space for maintenance and operations. An unobstructed walking space not less than 36 inches (914 mm) in width and 80 inches (2032 mm) in height shall be maintained throughout, allowing free access to not less than two sides of moving machinery and approaching each stop valve. Access to refrigeration machinery rooms shall be restricted to authorized personnel and posted with a permanent sign.

1106.11 Restricted Access. Access to the refrigeration machinery room shall be restricted to authorized personnel. Doors shall be clearly marked or permanent signs shall be posted at each entrance to indicate this restriction. [ASHRAE 15:8.11.8]

1106.12 Exits. Exits shall comply with the building code for special hazards.

1107.0 Machinery Room, Special Requirements.

1107.1 General. In cases specified in the rules of Section 1106.1, a refrigeration machinery room shall comply with the special requirements in accordance with Section 1107.1.1 through Section 1107.1.10, in addition to Section 1106.2.

1107.1.1 Flame-Producing Devices. There shall be no flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.

1107.1.2 Doors. Doors communicating with the building shall be approved, self-closing, tight-fitting fire doors.

1107.1.3 Walls, Floors, and Ceilings. Walls, floor, and ceiling shall be tight and of noncombustible construction. Walls, floor, and ceiling separating the refrigeration machinery room from other occupied spaces shall be not less than one-hour fire-resistive construction.

1107.1.4 Machinery Rooms. The refrigeration machinery room shall have a door that opens directly to the outdoors or through a vestibule equipped with self-closing, tight-fitting doors.

1107.1.5 Exterior Openings. Exterior openings, where present, shall not be under a fire escape or an open stairway.

1107.1.6 Sealing. All pipes piercing the interior walls, ceiling, or floor of such rooms shall be tightly sealed to the walls, ceiling, or floor through which they pass.

1107.1.7 Group A2L and B2L Refrigerants. Where refrigerant of Groups A2L or B2L are used, the requirements of Class 1, Division 2, of NFPA 70, shall not apply to the machinery room provided that the conditions in Section 1107.1.7.1 through Section 1107.1.7.3 are met.

1107.1.7.1 Mechanical Ventilation. The mechanical ventilation system in the machinery room is run continuously in accordance with Section 1106.2.5 and failure of the mechanical ventilation system actuates an alarm, or the mechanical ventilation system in the machinery room is activated by one or more refrigerant detectors, in accordance with the requirements of Section 1106.2.2.1 and Section 1106.2.2.2.

1107.1.7.2 Refrigeration Detectors. For the refrigerant detection required in Section 1106.2.2.1, detection of refrigerant concentration that exceeds 25 percent of the LFL or the upper detection limit of the refrigerant detector, whichever is lower, shall automatically de-energize the following equipment in the machinery room:

(a) refrigerant compressors
(b) refrigerant pumps
(c) normally-closed automatic refrigerant valves

1107.1.7.3 Machinery Rooms. The machinery room shall comply with Section 1107.1.8.

1107.1.8 Group A2, A3, B2, or B3 Refrigerants. Where any refrigerant of Groups A2, A3, B2, or B3 are used, the machinery room shall comply with Class 1, Division 2, of NFPA 70.

1107.1.9 Refrigeration Systems. As part of the mechanical ventilation system in accordance with Section 1106.2.4, refrigeration systems that contain more than 110 pounds (50 kg) of any Group A2L, A2, A3, B2L, B2, or B3, refrigerant shall have not less than one exhaust air inlet located adjacent to each system not more than 9 feet (3 m) away.

1107.1.10 Remote Control. Remote control of the mechanical equipment in the refrigeration machinery room shall be provided immediately outside the machinery room door solely for the purpose of shutting down the equipment in an emergency. Ventilation fans shall be on a separate electrical circuit and have a control switch located immediately outside the machinery room door.

1108.0 Refrigeration Machinery Room Equipment and Controls.

1108.1 General. Equipment, piping, ducts, vents, or similar devices that are not essential for the refrigeration process, maintenance of the equipment, or for the illumination, ventilation, or fire protection of the room shall not be placed in or pass through a refrigeration machinery room.

1108.2 Electrical. Electrical equipment and installations shall comply with the electrical code. The refrigeration machinery room shall not be classified as a hazardous location except as provided in Section 1107.1.7 or Section 1107.1.8.

1108.3 Emergency Shut-off. A clearly identified emergency shut-off switch of the break-glass type or with an approved tamper-resistant cover shall be provided immediately adjacent to and outside of the principal refrigeration machinery room entrance. The switch shall provide off-only control of refrigerant compressors, refrigerant pumps, and normally-closed automatic refrigerant valves located in the machinery room. For other than A1 and B2 refrigerants,
emergency shutoff shall be automatically activated by refrigerant Alarm 2 in accordance with Section 1106.2.2.1.

1108.4 Installation, Maintenance, and Testing. Detection and alarm systems in accordance with Section 1106.2.2.1 shall be installed, maintained, and tested in accordance with the fire code.

1108.5 Emergency Pressure Control System. Where required by the fire code, an emergency pressure control system shall be installed in accordance with applicable fire code requirements.

1109.0 Refrigeration Piping, Containers, and Valves.

1109.1 Materials. Materials used in the construction and installation of refrigerating systems shall be compatible with the refrigerant used. Materials shall not be used that will deteriorate due to the chemical action of the refrigerant, lubricant, or their combination of both where exposed to-in presence of air or moisture to a degree that poses a safety hazard. [ASHRAE 15:9.1.1] Refrigerant piping shall be metallic.

1109.1.1 Copper and Copper Alloy Pipe. Copper and copper alloy refrigeration piping, valves, fittings, and related parts used in the construction and installation of refrigeration systems shall be approved for the intended use. Refrigeration piping shall comply with ASME B31.5.

1109.1.2 Copper Linesets. Copper linesets shall comply with ASTM B280 or ASTM B1003.

1109.1.3 Iron and Steel. Iron and steel refrigeration piping, valves, fittings, and related parts shall be approved for the intended use. Pipe exceeding 2 inches (50 mm) iron pipe size shall be electric-resistance welded or seamless pipe. Refrigeration piping shall comply with ASME B31.5.

1109.1.4 Prohibited Contact. Aluminum, zinc, magnesium, or their alloys shall not be used in contact with methyl chloride. Magnesium alloys shall not be used where in contact with halogenated refrigerants. [ASHRAE 15:9.1.2]

1109.2 Joints. Iron or steel pipe joints shall be of approved threaded, flanged, or welded types. Exposed threads shall be tinned or coated with an approved corrosion inhibitor. Copper or copper alloy pipe joints of iron pipe size shall be of approved threaded, flanged, press-connect or brazed types. Copper tubing joints and connections shall be connected by approved flared, lapped, swaged, or brazed joints, soldered joints, or mechanical joints that comply with UL 207 either individually or as part of an assembly or a system by an approved nationally recognized laboratory. Piping and tubing shall be installed so as to prevent vibration and strains at joints and connections.

1109.3 Penetration of Piping. Refrigerant piping shall not penetrate floors, ceilings, or roofs.

Exceptions:
(1) Penetrations connecting the basement and the first floor.
(2) Penetrations connecting the top floor and a machinery penthouse or roof installation.
(3) Penetrations connecting adjacent floors served by the refrigeration system.
(4) Penetrations of a direct system where the refrigerant concentration does not exceed that listed in Table 1102.3 for the smallest occupied space through which the refrigerant piping passes.
(5) In other than industrial occupancies and where the refrigerant concentration exceeds that listed in Table 1102.3 for the smallest occupied space, penetrations that connect separate pieces of equipment that are in accordance with one of the following:
(a) Enclosed by an approved gastight, fire-resistive duct or shaft with openings to those floors served by the refrigerating system.
(b) Located on the exterior wall of a building where vented to the outdoors or to the space served by the system and not used as an air shaft, closed court, or similar space. [ASHRAE 15:8.10.3]

1109.4 Location of Refrigeration Piping. Refrigerant piping crossing an open space that affords passageway in a building shall be not less than 7.25 feet (2210 mm) above the floor unless the piping is located against the ceiling of such space and is permitted by the Authority Having Jurisdiction. [ASHRAE 15:8.10.1]

1109.4.1 Protection from Mechanical Damage. Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be located in an elevator, dumbwaiter, or other shaft containing a moving object, or in a shaft that has openings to living quarters, or to means of egress. Refrigerant piping shall not be installed in an enclosed public stairway, stair landing, or means of egress. [ASHRAE 15:8.10.2]

1109.5 Underground Piping. Refrigerant piping placed underground shall be protected against corrosion.

1109.5.1 Piping in Concrete Floors. Refrigerant piping installed in concrete floors shall be encased in a pipe duct. Refrigerant piping shall be isolated and supported to prevent damaging vibration, stress, or corrosion. [ASHRAE 15:8.10.4]

1109.6 Support. In addition to the requirements of Section 1105.2, piping and tubing shall be securely fastened to a permanent support within 6 feet (1829 mm) following the first bend in such tubing from the compressor and within 2 feet (610 mm) of each subsequent bend or angle. Piping and tubing shall be supported at points not more than 15 feet (4572 mm) apart.

1109.7 Pipe Enclosure. Refrigerant piping and tubing shall be installed so that it is not subject to damage from an external source. Soft annealed copper tubing shall not exceed 1/8 inches (35 mm) nominal size. Mechanical joints, other than approved press-connect joints, shall not be made on tubing exceeding 1/4 of an inch (20 mm) nominal size. Soft annealed copper tubing conveying refrigerant shall be enclosed in iron or steel piping and fittings, or in conduit, molding, or raceway that will protect the tubing against mechanical injury from an exterior source.
Exceptions:
(1) Tubing entirely within or tubing within 5 feet (1524 mm) of a refrigerant compressor where so located that it is not subject to external injury.
(2) Copper tubing serving a dwelling unit, where such tubing contains Group A1 refrigerant and is placed in locations not subject to damage from an external source.

1109.8 Visual Inspection. Refrigerant piping and joints erected on the premises shall be exposed to view for visual inspection prior to being covered or enclosed.

Exception: Copper tubing enclosed in iron or steel piping conduit, molding, or raceway, provided there are no fittings or joints concealed therein.

1109.9 Condensation. Piping and fittings that convey brine, refrigerant, or coolants that during normal operation are capable of reaching a surface temperature below the dew point of the surrounding air and that are located in spaces or areas where condensation will cause a hazard to the building occupants or damage to the structure, electrical or other equipment shall be protected to prevent such damage.

1109.10 Identification. Piping shall be in accordance with the reference standard for identification. The type of refrigerant, function and pressure shall be indicated.

1110.0 Valves.
1110.1 More than 6.6 Pounds of Refrigerant. Systems containing more than 6.6 pounds (2.99 kg) of refrigerant shall have stop valves installed at the following locations:
(1) The suction inlet of a compressor, compressor unit, or condensing unit.
(2) The discharge of a compressor, compressor unit, or condensing unit.
(3) The outlet of a liquid receiver.

Exceptions:
(1) Systems that have a refrigerant pumpout function capable of storing the refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant.
(2) Self-contained systems. [ASHRAE 15:9.12.4]

1110.2 More than 110 Pounds of Refrigerant. Systems containing more than 110 pounds (49.9 kg) of refrigerant shall have stop valves installed at the following locations:
(1) The suction inlet of a compressor, compressor unit, or condensing unit.
(2) The discharge outlet of a compressor, compressor unit, or condensing unit.
(3) The inlet of a liquid receiver, except for self-contained systems or where the receiver is an integral part of the condenser or condensing unit.
(4) The outlet of a liquid receiver.
(5) The inlets and outlets of condensers where more than one condenser is used in parallel in the systems.

Exception: Systems that have a refrigerant pumpout function capable of storing the refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant or self-contained systems. [ASHRAE 15:9.12.5]

1110.3 Support. Stop valves installed in copper refrigerant lines of ⅜ inch (20 mm) or less outside diameter shall be supported independently of the tubing or piping.

1110.4 Access. Stop valves required by Section 1110.0 shall be readily accessible from the refrigeration machinery room floor or a level platform.

1110.5 Identification. Stop valves shall be identified by tagging in accordance with the reference standard for identification. A valve chart shall be mounted under glass at an approved location near the principal entrance to a refrigeration machinery room.

1111.0 Pressure-Limiting Devices.
1111.1 Where Required. Pressure-limiting devices complying with Section 1111.2 through Section 1111.4 shall be provided for compressors on all systems operating above atmospheric pressure.

Exception: Pressure limiting devices are not required for listed factory-sealed systems containing less than 22 pounds (9.9 kg) of Group A1 refrigerant. [ASHRAE 15:9.9.1]

1111.2 Setting. Pressure limiting devices shall be set in accordance with one of the following:
(1) For positive displacement compressors:
   (a) When systems are protected by a highside pressure relief device, the compressor’s pressure limiting device shall be set not more than 90 percent of the operating pressure for the highside pressure relief device.
   (b) When systems are not protected by a highside pressure relief device, the compressor’s pressure limiting device shall be set not more than the system’s highside design pressure.
(2) For nonpositive displacement compressors:
   (a) When systems are protected by a highside pressure relief device, the compressor’s pressure limiting device shall be set not more than 90 percent of the operating pressure for the highside pressure relief device.
   (b) When systems are protected by a lowside pressure relief device that is only subject to lowside pressure, and is provided with a permanent relief path between the systems’ highside and lowside, without intervening valves, the compressor’s pressure limiting device shall be set not more than the systems’ highside design pressure. [ASHRAE 15:9.9.2]

1111.3 Location. Stop valves shall not be installed between the pressure imposing element and pressure limiting devices serving compressors. [ASHRAE 15:9.9.3]

1111.4 Emergency Stop. Activation of a pressure-limiting device shall stop the action of the pressure-imposing element. [ASHRAE 15:9.9.4]

1112.0 Pressure-Relief Devices.
1112.1 General. Refrigeration systems shall be protected by a pressure-relief device or other approved means to safely
relieve pressure due to fire or abnormal conditions. [ASHRAE 15:9.4.1]

**1112.2 Positive Displacement Compressor.** A positive displacement compressor with a stop valve in the discharge connection shall be equipped with a pressure-relief device that is sized, and with a pressure setting, in accordance with the compressor manufacturer to prevent rupture of the compressor or to prevent the pressure from increasing to more than 10 percent above the maximum allowable working pressure of components located in the discharge line between the compressor and the stop valve or in accordance with Section 1113.5, whichever is larger. The pressure-relief device shall discharge into the low-pressure side of the system or in accordance with Section 1112.10.

Exception: Hermetic refrigerant motor-compressors that are listed and have a displacement not more than 50 cubic feet per minute (1.42 m³/min).

The relief device(s) shall be sized based on compressor flow at the following conditions:

1. For compressors in single-stage systems and high-stage compressors of other systems, the flow shall be calculated based on 50°F (10°C) saturated suction temperature at the compressor suction.
2. For low-stage or booster compressors in compound systems, the compressors that are capable of running only where discharging to the suction of a high-stage compressor, the flow shall be calculated based on the saturated suction temperature equal to the design operating intermediate temperature.
3. For low-stage compressors in cascade systems, the compressors that are located in the lower-temperature stage(s) of cascade systems, the flow shall be calculated based on the suction pressure being equal to the pressure setpoint of the pressure-relieving devices that protect the lowside of the stage against overpressure.

Exceptions: For Section 1112.2(1), Section 1112.2(2), and Section 1112.2(3), the discharge capacity of the relief device shall be permitted to be the minimum regulated flow rate of the compressor where the following conditions are met:

1. The compressor is equipped with capacity regulation.
2. Capacity regulation actuates to a flow at not less than 90 percent of the pressure-relief device setting.
3. A pressure-limiting device is installed and set in accordance with the requirements of Section 1111.0. [ASHRAE 15:9.8]

**1112.3 Liquid-Containing Portions of Systems.** Liquid-containing portions of systems, including piping, that is isolated from pressure-relief devices required elsewhere, and that develops pressures exceeding their design pressures due to temperature rise, shall be protected by the installation of pressure-relief devices.

**1112.4 Evaporators.** Heat exchanger coils located downstream, or upstream within 18 inches (457 mm), of a heating source and capable of being isolated shall be fitted with a pressure-relief device that discharges to another part of the system in accordance with Section 1112.5 through Section 1112.5.2 or outside any enclosed space in accordance with Section 1112.10. The pressure relief device shall be connected at the highest possible location of the heat exchanger or piping between the heat exchanger and its manual isolation valves.

Exceptions:

1. Relief valves shall not be required on heat exchanger coils that have a design pressure more than 110 percent of refrigerant saturation pressure when exposed to the maximum heating source temperature.
2. A relief valve shall not be required on self-contained or unit systems where the volume of the lowside of the system, which is shut off by valves, is more than the specific volume of the refrigerant at critical conditions of temperature and pressure, as determined in accordance with Equation 1112.4.

\[
V_1 / (W_1 - (V_2 - V_1) / V_{gc}) \quad \text{(Equation 1112.4)}
\]

Where:

- \(V_1\) = Lowside volume, cubic foot (m³).
- \(V_2\) = Total volume of system, cubic foot (m³).
- \(W_1\) = Total weight of refrigerant in system, pounds (kg).
- \(V_{gt}\) = Specific volume of refrigerant vapor at 110°F (43°C), cubic feet per pound (m³/kg).
- \(V_{gc}\) = Specific volume at critical temperature and pressure, cubic feet per pound (m³/kg). [ASHRAE 15:9.4.4]

**1112.5 Hydrostatic Expansion.** Pressure rise resulting from hydrostatic expansion due to temperature rise of liquid refrigerant trapped in or between closed valves shall be addressed in accordance with Section 1112.5.1 and Section 1112.5.2. [ASHRAE 15:9.4.3]

**1112.5.1 Hydrostatic Expansion During Normal Operation.** Where trapping of liquid with subsequent hydrostatic expansion is capable of occurring automatically during normal operation or during standby, shipping, or power failure, engineering controls shall be used that are capable of preventing the pressure from exceeding the design pressure. Acceptable engineering controls include but are not limited to the following:

1. Pressure relief device to relieve hydrostatic pressure to another part of the system.
2. Re seating pressure relief valve to relieve the hydrostatic pressure to an approved treatment system. [ASHRAE 15:9.4.3.1]

**1112.5.2 Hydrostatic Expansion During Maintenance.** Where trapping of liquid with subsequent hydrostatic expansion is capable of occurring only during maintenance—i.e., when personnel are performing maintenance tasks—either engineering or administrative controls shall be used to relieve or prevent the hydrostatic overpressure. [ASHRAE 15:9.4.3.2]

**1112.6 Actuation.** Pressure-relief devices shall be direct-pressure actuated or pilot operated. Pilot-operated pressure-relief valves shall be self-actuated, and the main valve shall
Pressure-relief systems designed for vapor shall comply with Section 1112.11 Discharge from Pressure-Relief Devices. A three-way valve, used in conjunction with the dual relief valve in accordance with Section 1113.6, shall not be considered a stop valve. [ASHRAE 15:9.4.6]

1112.8 Location. Pressure-relief devices shall be connected directly to the pressure vessel or other parts of the system protected thereby. These devices shall be connected above the liquid refrigerant level and installed so that they are accessible for inspection and repair, and so that they are not capable of being readily rendered inoperative.

Exception: Where fusible plugs are used on the highside, they shall be located above or below the liquid refrigerant level. [ASHRAE 15:9.4.8]

1112.9 Materials. The seats and discs of pressure-relief devices shall be constructed of compatible material to resist refrigerant corrosion or other chemical action caused by the refrigerant. Seats or discs of cast iron shall not be used. Seats and discs shall be limited in distortion, by pressure or other cause, to a set pressure change of not more than 5 percent in a span of five years. [ASHRAE 15:9.4.9]

1112.10 Pressure-Relief Device Settings. Pressure-relief valves shall start to function at a pressure not exceeding the design pressure of the parts of the system protected.

Exception: Relief valves that discharge into other parts of the system shall comply with Section 1112.10.1. [ASHRAE 15:9.5.1]

1112.10.1 Rupture Member Setting. Rupture members used in lieu of, or in series with, a relief valve shall have a nominal rated rupture pressure not exceeding the design pressure of the parts of the system protected. The conditions of application shall comply with ASME BPVC Section VIII. The size of rupture members installed ahead of relief valves shall not be less than the relief-valve inlet. [ASHRAE 15:9.5.2]

1112.11 Discharge from Pressure-Relief Devices. Pressure-relief systems designed for vapor shall comply with Section 1112.11.1 through Section 1112.11.4. [ASHRAE 15:9.7.8.1]

1112.11.2 Discharging Location Exterior to Building. Pressure-relief devices designed to discharge external to the refrigeration system shall be arranged to discharge outside of a building and shall be in accordance with the following:

1. The point of vent discharge shall be located not less than 15 feet (4572 mm) above the adjoining ground level.

Exception: Outdoor systems containing Group A1 refrigerant shall be permitted to discharge at any elevation where the point of discharge is located in an access-controlled area accessible to authorized personnel only.

2. The point of vent discharge shall be located not less than 20 feet (6096 mm) from windows, building ventilation openings, pedestrian walkways, or building exits.

3. For heavier-than-air refrigerants, the point of vent discharge shall be located not less than 20 feet (6096 mm), horizontally from below-grade walkways, entrances, pits or ramps where a release of the entire system charge into such a space would yield a concentration of refrigerant in excess of the RCL. The direct discharge of a relief vent into enclosed outdoor spaces, such as a courtyard with walls on all sides, shall not be permitted where a release of the entire system charge into such a space would yield a concentration of refrigerant in excess of the RCL. The volume for the refrigerant concentration calculation shall be determined using the gross area of the space and a height of 8.2 feet (2499 mm), regardless of the actual height of the enclosed space.

4. The termination point of a vent discharge line shall be made in a manner that prevents discharged refrigerant from spraying directly onto personnel that are capable of being in the vicinity.

5. The termination point of vent discharge line shall be made in a manner that prevents foreign material or debris from entering the discharge piping.

6. Relief vent lines that terminate vertically upward and are subject to moisture entry shall be provided with a drip pocket having a length of not less than 24 inches (610 mm) and having the size of the vent discharge pipe. The drip pocket shall be installed to extend below the first change in vent pipe direction and shall be fitted with a valve or drain plug to permit removal of accumulated moisture. [ASHRAE 15:9.7.8.2]

1112.11.3 Internal Relief. Pressure-relief valves designed to discharge from a higher-pressure vessel into a lower pressure vessel internal to the system shall comply with the following:

1. The pressure-relief valve that protects the higher-pressure vessel shall be selected to deliver capacity in accordance with Section 1113.5 without exceed-
ing the maximum allowable working pressure of the higher-pressure vessel accounting for the change in mass flow capacity due to the elevated backpressure.

(2) The capacity of the pressure-relief valve protecting the part of the system receiving a discharge from a pressure-relief valve protecting a higher-pressure vessel shall be not less than the sum of the capacity required in Section 1113.5 plus the mass flow capacity of the pressure-relief valve discharging into that part of the system.

(3) The design pressure of the body of the relief valve used on the higher-pressure vessel shall be rated for operation at the design pressure of the higher-pressure vessel in both pressure-containing areas of the valve. [ASHRAE 15:9.7.8.3]

1112.11.4 Discharge Location, Special Requirements. Additional requirements for relief device discharge location and allowances shall apply for specific refrigerants in accordance with Section 1112.11.4.1. [ASHRAE 15:9.7.8.4]

1112.11.4.1 Water (R-718). Where water is the refrigerant, discharge to a floor drain shall be permitted where the following conditions are met:

(1) The pressure-relief device set pressure shall not exceed 15 psig (103 kPa).

(2) The floor drain shall be sized to handle the flow rate from a single broken tube in a refrigerant-containing heat exchanger.

(3) The Authority Having Jurisdiction finds it acceptable that the working fluid, corrosion inhibitor, and other additives used in this type of refrigeration system are permitted to infrequently be discharged to the sewer system, or a catch tank that is sized to handle the expected discharge shall be installed and equipped with a normally closed drain valve and an overflow line to drain. [ASHRAE 15:9.7.8.4.1]

1112.12 Discharge Piping. The piping used for pressure-relief device discharge shall be in accordance with Section 1112.12.1 through Section 1112.12.5. [ASHRAE 15:9.7.9]

1112.12.1 Piping Connection. Piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging of the pipe upon operation of a fusible plug or rupture member. [ASHRAE 15:9.7.9.1]

1112.12.2 Pipe Size. The size of the discharge pipe from the pressure-relief device or fusible plug shall not be less than the outlet size of the pressure-relief device or fusible plug. [ASHRAE 15:9.7.9.2]

1112.12.3 Maximum Length. The maximum length of the discharge piping installed on the outlet of pressure-relief devices and fusible plugs discharging to the atmosphere shall be determined in accordance with Section 1112.12.4 and Section 1112.12.5. See Table 1112.12.3 for the allowable flow capacity of various equivalent lengths of single discharge piping vents for conventional pressure-relief valves. [ASHRAE 15:9.7.9.3]

For SI units: 1 foot = 304.8 mm, 1 pound-force per square inch = 6.8947 kPa

1112.12.4 Design Back Pressure. The design back pressure due to flow in the discharge piping at the outlet of pressure-relief devices and fusible plugs, discharging to atmosphere, shall be limited by the allowable equivalent length of piping determined in accordance with Equation 1112.12.4(1).

\[
L = \frac{0.2146 \cdot d^2 \left( P_2 - P_0 \right)}{f \cdot C_r} - \frac{d \cdot \ln \left( \frac{P_0}{P_2} \right)}{6 \cdot f}
\]

Where:

\( L \) = Equivalent length of discharge piping, feet.
\( C_r \) = Rated capacity as stamped on the relief device in pounds per minute (lb/min), or in SCFM multiplied by 0.0764, or as calculated in Section 1112.14 for a rupture member or fusible plug, or as adjusted for reduced capacity due to piping in accordance with the manufacturer of the device, or as adjusted for reduced capacity due to piping as estimated by an approved method.
\( f \) = Moody friction factor in fully turbulent flow.
\( d \) = Inside diameter of pipe or tube, inches.
\( \ln \) = Natural logarithm.
\( P_2 \) = Absolute pressure at outlet of discharge piping, psia.
\( P_0 \) = Allowed back pressure (absolute) at the outlet of pressure relief device, (psia).

For SI units: 1 foot = 304.8 mm, 1 pound-force per square inch = 6.8947 kPa, 1 pound per minute = 0.00756 kg/s
Unless the maximum allowable back pressure \( (P_0) \) is specified by the relief valve manufacturer, the following maximum allowable back pressure values shall be used for \( P_0 \), where \( P \) is the set pressure and \( P_a \) is atmospheric pressure at the nominal elevation of the installation (see Table 1112.12.3):

For conventional relief valves: 15 percent of set pressure:

\[
P_0 = (0.15 \cdot P) + P_a \quad \text{[Equation 1112.12.4(2)]}
\]

For balanced relief valves: 25 percent of set pressure:

\[
P_0 = (0.25 \cdot P) + P_a \quad \text{[Equation 1112.12.4(3)]}
\]

For rupture disks alone: fusible plugs, and pilot operated relief devices, 50 percent of set pressure:

\[
P_0 = (0.50 \cdot P) + P_a \quad \text{[Equation 1112.12.4(4)]}
\]

For fusible plugs, \( P \) shall be the saturated absolute pressure for the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller. [ASHRAE 15:9.7.9.3.2]

1112.12.5 Simultaneous Operation. Where outlets of two or more relief devices or fusible plugs, which are expected to operate simultaneously, connect to a common discharge pipe, the common pipe shall be sized large enough to prevent the outlet back pressure at each relief device from exceeding the maximum allowable outlet back pressure in accordance with Section 1112.12.4. [ASHRAE 15:9.7.9.3.3]

1112.13 Rating of Pressure-Relief Device. The rated discharge capacity of a pressure-relief device expressed in pounds of air per minute (kg/s), shall be determined in accordance with ASME BPVC Section VIII. Pipe and fittings between the pressure-relief valve and the parts of the system it protects shall have not less than the area of the pressure-relief valve inlet area. [ASHRAE 15:9.7.6]

1112.14 Rating of Rupture Members and Fusible Plugs. The rated discharge capacity of a rupture member or fusible plug discharging to atmosphere under critical flow conditions, in pounds of air per minute (kg/s), shall be determined in accordance with the following formulas:

\[
C = 0.64P_a d^2 \quad \text{[Equation 1112.14(1)]}
\]

\[
d = 1.25 \sqrt{C/P} \quad \text{[Equation 1112.14(2)]}
\]

Where:

- \( C \) = Rated discharge capacity of air, pounds per minute.
- \( d \) = Smallest internal diameter of the inlet pipe, retaining flanges, fusible plug, or rupture member; inches.

For rupture members:

\[
P_f = \frac{(\text{rated pressure in psig } \times 1.1)}{14.7} \quad \text{[Equation 1112.14(3)]}
\]

For fusible plugs:

\[
P_f = \text{Absolute saturation pressure, corresponding to the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, pound-force per square inch atmosphere, psia. [ASHRAE 15:9.7.7]}
\]

For SI units: 1 inch = 25.4 mm, 1 pound-force per square inch = 6.8947 kPa, 1 pound per minute = 0.00756 kg/s

1113.0 Overpressure Protection.

1113.1 General. Pressure vessels shall be provided with overpressure protection in accordance with ASME BPVC Section VIII. Pressure vessels containing liquid refrigerant that are capable of being isolated by stop valves from other parts of the refrigerating system shall be provided with overpressure protection. Pressure-relief devices or fusible plugs shall be sized in accordance with Section 1113.5. [ASHRAE 15:9.7.1, 9.7.2]

1113.2 Type of Protection. Pressure vessels with an internal gross volume of 3 cubic feet (0.1 m³) or less shall use one or more pressure-relief devices or a fusible plug. Pressure vessels of more than 3 cubic feet (0.1 m³) but less than 10 cubic feet (0.28 m³) internal gross volume shall use one or more pressure-relief devices; fusible plugs shall not be used. [ASHRAE 15:9.7.2.1, 9.7.2.2]

1113.3 Discharging Into Lowside of System. For pressure-relief valves discharging into the lowside of the system, a single relief valve (not rupture member) of the required relieving capacity shall not be used on vessels of 10 cubic feet (0.28 m³) or more internal gross volume except under the conditions permitted in Section 1112.10.1. [ASHRAE 15:9.7.3]

1113.4 Parallel Pressure-Relief Devices. Two or more pressure-relief devices in parallel to obtain the required capacity shall be considered as one pressure-relief device. The discharge capacity shall be the sum of the capacities required for each pressure vessel being protected.

1113.5 Discharge Capacity. The minimum required discharge capacity of the pressure-relief device or fusible plug for a pressure vessel shall be determined in accordance with Equation 1113.5:

\[
C = fDL \quad \text{(Equation 1113.5)}
\]

Where:

- \( C \) = Minimum required discharge capacity of the relief device expressed as mass flow of air, pounds per minute (kg/s).
- \( D \) = Outside diameter of vessel, feet (m).
- \( L \) = Length of vessel, feet (m).
- \( f \) = Factor dependent upon type of refrigerant from Table 1113.5.

Where combustible materials are used within 20 ft (6096 mm) of a pressure vessel, the value of \( f \) shall be multiply by 2.5. Equation 1113.5 is based on fire conditions, other heat sources shall be calculated separately. Where one pressure-relief device or fusible plug is used to protect more than one
TABLE 1113.5
RELIEF DEVICES CAPACITY FACTOR*
[ASHRAE 15: TABLE 9.7.5]

<table>
<thead>
<tr>
<th>RELIEF VALVE</th>
<th>VALUE OF F</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-23, R-170, R-744, R-1150, R-508A, R-508B</td>
<td>1</td>
</tr>
<tr>
<td>R-13, R-13B1, R-503</td>
<td>2</td>
</tr>
<tr>
<td>R-14</td>
<td>2.5</td>
</tr>
<tr>
<td>Other applications:</td>
<td></td>
</tr>
<tr>
<td>R-718</td>
<td>0.2</td>
</tr>
<tr>
<td>R-717</td>
<td>0.5</td>
</tr>
<tr>
<td>R-11, R-32, R-113, R-123, R-142b, R-152a, R-290, R-600, R-600a, R-764</td>
<td>1</td>
</tr>
<tr>
<td>R-143a, R-402B, R-403A, R-407A, R-408A, R-413A</td>
<td>2</td>
</tr>
</tbody>
</table>

* In accordance with Section 1102.2, ammonia refrigeration systems are not regulated by this chapter. R-717 (ammonia) is included in this table because the table is extracted from ASHRAE 15 and is not capable of being modified.

1113.6 Three-Way Valve. Pressure vessels of 10 cubic feet (0.28 m³) or more internal gross volume shall use one or more rupture member(s) or dual pressure-relief valves where discharging to the atmosphere. Dual pressure-relief valves shall be installed with a three-way valve to allow testing or repair. Where dual relief valves are used, the valve shall comply with Section 1113.5.

Exception: A single relief valve shall be permitted on pressure vessels of 10 cubic feet (0.28 m³) or more internal gross volume where in accordance with the following conditions:
1. The relief valves are located on the lowside of the system.
2. The vessel is provided with shutoff valves designed to allow pumpdown of the refrigerant charge of the pressure vessel.
3. Other pressure vessels in the system are separately protected in accordance with Section 1113.1. [ASHRAE 15:9.7.2.3]

1114.0 Special Discharge Requirements.

1114.1 General. Systems containing other than Group A1 or B1 refrigerants shall discharge to atmosphere through an approved flaring device.

Exceptions:
1. Where the Authority Having Jurisdiction determines upon review of a rational engineering analysis that fire, health, or environmental hazards will not result from the proposed atmospheric release.
2. Lithium bromide absorption system using water as the refrigerant.

1114.2 Design Requirements. Flaring devices shall be designed to incinerate the entire discharge. The products of refrigerant incineration shall not pose health or environmental hazards. Incineration shall be automatic upon initiation of discharge, shall be designed to prevent blow-back, and shall not expose structures or materials to the threat of fire. Standby fuel, such as L.P.-Gas, and standby power shall have the capacity to operate for one and a half times the required time for complete incineration of the charge.

1114.3 Testing. Flaring systems shall be tested to demonstrate their safety and effectiveness. A report from an approved agency shall be submitted detailing the emission products from the system as installed.

1115.0 Labeling and Identification.

1115.1 General. In addition to labels required elsewhere in this chapter, a refrigeration system shall be provided with identification labels in accordance with Section 1115.2 and Section 1115.3.

1115.2 Volume and Type. A condenser, receiver, absorber, accumulator and similar equipment having an internal volume of more than 3 cubic feet (0.1 m³) and containing refrigerant shall be equipped with a permanent label setting forth the type of refrigerant in such vessel.

1115.3 Permanent Sign. In a refrigeration machinery room and for a direct refrigerating system of more than 10 horsepower (7.5 kW), there shall be a permanent sign at an approved location giving the following information:
1. Name of contractor installing the equipment.
2. Name and number designation of refrigerant in system.
3. Pounds of refrigerant in system.

1115.4 Marking of Pressure-Relief Devices. Pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or an assembler as defined in accordance with ASME BPVC Section VIII. Each pressure-relief valve shall be marked by the manufacturer or assembler with the data required in accordance with ASME BPVC Section VIII.

Exception: Relief valves for systems with design pressures of 15 pounds-force per square inch gauge (psig) (103 kPa) or less shall be marked by the manufacturer with the pressure-setting capacity. [ASHRAE 15:9.6.1]

1115.4.1 Rupture Members. Rupture members for refrigerant pressure vessels shall be marked with the data required in accordance with ASME BPVC Section VIII. [ASHRAE 15:9.6.2]

1115.4.2 Fusible Plugs. Fusible plugs shall be marked with the melting temperatures in °F (°C). [ASHRAE 15:9.6.3]
1116.0 Testing of Refrigeration Equipment.

1116.1 Factory Tests. Refrigerant-containing parts of unit systems shall be tested and proved tight by the manufacturer at not less than the design pressure for which they are rated. Pressure vessels shall be tested in accordance with Section 1117.0. [ASHRAE 15:9.14.1]

1116.1.1 Testing Procedure. Tests shall be performed with dry nitrogen or another nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them shall not be used. The means used to build up the test pressure shall have a pressure-limiting device or a pressure-reducing device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system’s components.

Exceptions:
(1) Mixtures of dry nitrogen, inert gases, nonflammable refrigerants permitted for factory tests.
(2) Mixtures of dry nitrogen, inert gases, or a combination of them with flammable refrigerants in concentrations not exceeding the lesser of a refrigerant weight fraction (mass fraction) of 5 percent or 25 percent of the LFL shall be permitted for factory tests.
(3) Compressed air without added refrigerant shall be permitted for factory tests provided the system is subsequently evacuated to less than 0.039 inch of mercury (0.132 kPa) before charging with refrigerant. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the refrigerant. [ASHRAE 15:9.14.1.1]

1116.1.2 Applied Pressure. The test pressure applied to the highside of each factory-assembled refrigerating system shall be not less than the design pressure of the highside. The test pressure applied to the lowside of a factory-assembled refrigerating system shall be not less than the design pressure of the lowside.

1116.1.3 Design Pressure of 15 psig or Less. Units with a design pressure of 15 psig (103 kPa) or less shall be tested at a pressure not less than 1.33 times the design pressure, and shall be proved leak-tight at not less than the lowside design pressure. [ASHRAE 15:9.14.3]

1116.2 Field Tests. Refrigerant-containing parts of a system that is field-erected shall be tested and proved tight after complete installation and before the operation. The high and low sides of each system shall be tested and proved tight at not less than the lower of the pressure in Table 1116.2 or the setting of the pressure-relief device.

Exceptions:
(1) Compressors, condensers, evaporators, coded pressure vessels, safety devices, pressure gauges, control mechanisms, and systems that are factory tested.
(2) Refrigeration systems containing Group R-22, not exceeding 5 tons of refrigeration capacity (18 kW), and field-piped using approved, factory-charged line sets shall be permitted to be proved tight by observing retention of pressure on a set of charging gauges and soaping connections while the system is operating.

<table>
<thead>
<tr>
<th>REFRIGERANT NUMBER</th>
<th>HIGHSIDE WATER COOLED</th>
<th>HIGHSIDE AIR COOLED</th>
<th>LOWSIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>15</td>
<td>35</td>
<td>15</td>
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<tr>
<td>12</td>
<td>140</td>
<td>220</td>
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<tr>
<td>22</td>
<td>230</td>
<td>360</td>
<td>230</td>
</tr>
<tr>
<td>113</td>
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<td>15</td>
<td>15</td>
</tr>
<tr>
<td>114</td>
<td>40</td>
<td>80</td>
<td>40</td>
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<tr>
<td>115</td>
<td>275</td>
<td>340</td>
<td>275</td>
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<tr>
<td>123</td>
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<td>30</td>
<td>15</td>
</tr>
<tr>
<td>134a</td>
<td>150</td>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>152a</td>
<td>130</td>
<td>220</td>
<td>130</td>
</tr>
<tr>
<td>500</td>
<td>165</td>
<td>265</td>
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<td>502</td>
<td>250</td>
<td>385</td>
<td>250</td>
</tr>
<tr>
<td>744*</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* Special design required; test pressures typically exceed 1000 psig (6895 kPa).

<table>
<thead>
<tr>
<th>TABLE 1116.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD LEAK TEST PRESSURES (psig)*</td>
</tr>
<tr>
<td>REFRIGERANT NUMBER</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>22</td>
</tr>
<tr>
<td>113</td>
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<td>114</td>
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<tr>
<td>115</td>
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<td>123</td>
</tr>
<tr>
<td>134a</td>
</tr>
<tr>
<td>152a</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>502</td>
</tr>
<tr>
<td>744*</td>
</tr>
</tbody>
</table>

For SI units: 1 pound-force per square inch gauge = 6.8947 kPa

1116.3 Test Gases. Tests shall be performed with dry nitrogen or other nonflammable, nonreactive, dried gas. Oxygen, air, or mixtures containing them shall not be used. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system’s components.

Exceptions:
(1) Mixtures of dry nitrogen, inert gases, or a combination of them with nonflammable refrigerant in concentrations not exceeding 5 percent shall be permitted for tests.
(2) Mixtures of dry nitrogen, inert gases, or a combination of them with flammable refrigerants in concentrations not exceeding the lower of a refrigerant weight fraction (mass fraction) of 5 percent or 25 percent of the LFL shall be permitted for tests.
(3) Compressed air without added refrigerant shall be permitted for tests, provided the system is subsequently evacuated to less than 1000 microns (0.133 kPa) before charging with refrigerant. The required evacuation level is atmospheric pressure for systems using R-718 (water) or R-744 (carbon dioxide) as the refrigerant. [ASHRAE 15:9.14.1.1]

1116.4 Declaration. A dated declaration of test shall be provided for systems containing more than 55 pounds (24.9 kg)
of refrigerant. The declaration shall give the name of the refrigerant and the field test pressure applied to the highside and the lowside of the system. The declaration of test shall be signed by the installer and, where an inspector is present at the tests, the inspector shall also sign the declaration. Where requested, copies of this declaration shall be furnished to the Authority Having Jurisdiction. [ASHRAE 15:10.2]

1116.5 Brine Systems. Brine-containing portions of a system shall be tested at one and a half times the design pressure of the system using brine as the test fluid.

1117.0 Refrigerant-Containing Pressure Vessels.  
1117.1 Inside Dimensions 6 inches or Less. Pressure vessels having inside dimensions of 6 inches (152 mm) or less shall comply with the following:

(1) Be listed Listed either individually or as part of an assembly by an approved, nationally recognized testing laboratory or-

(2) Marked directly on the vessel or on a nameplate attached to the vessel in accordance with a “U” or “UM” symbol signifying compliance with ASME BPVC Section VIII, or

(3) Where requested by the Authority Having Jurisdiction, the manufacturer shall provide documentation to confirm that the vessel meets the design, fabrication, and testing requirements in accordance with ASME BPVC Section VIII.

Exception: Vessels having an internal or external design pressure of 15 psig (103 kPa) or less.

Pressure vessels having inside dimensions of 6 inches (152 mm) or less shall be protected by either a pressure-relief device or a fusible plug. [ASHRAE 15:9.3.1.1]

1117.1.1 Pressure-Relief Device. Where a pressure-relief device is used to protect a pressure vessel having an inside dimension of 6 inches (152 mm) or less, the ultimate strength of the pressure vessel so protected shall withstand a pressure of not less than 3.0 times the design pressure. [ASHRAE 15:9.3.1.2]

1117.1.2 Fusible Plug. Where a fusible plug is used to protect a pressure vessel having an inside diameter of 6 inches (152 mm) or less, the ultimate strength of the pressure vessel so protected shall withstand a pressure 2.5 times the saturation pressure of the refrigerant used at the temperature stamped on the fusible plug or 2.5 times the critical pressure of the refrigerant used, whichever is less. [ASHRAE 15:9.3.1.3]

1117.2 Inside Dimensions More than 6 inches. Pressure vessels having an inside diameter exceeding 6 inches (152 mm) and having an internal or external design pressure of more than 15 psig (103 kPa) shall be directly marked, or marked on a nameplate in accordance with a “U” or “UM” symbol signifying compliance with the rules of ASME BPVC Section VIII. [ASHRAE 15:9.3.2]

1117.3 Pressure Vessels for 15 psig or Less. Pressure vessels having an internal or external design pressure of 15 psig (103 kPa) or less shall have an ultimate strength to withstand not less than 3.0 times the design pressure and shall be tested with a pneumatic test pressure of not less than 1.25 times the design pressure or a hydrostatic test pressure of not less than 1.5 times the design pressure. [ASHRAE 15:9.3.3]

1118.0 Maintenance and Operation.  
1118.1 General. Refrigeration systems shall be operated and maintained as required by the fire code.

Part II – Cooling Towers.

1119.0 General.  
1119.1 Applicability. Cooling towers, evaporative condensers, and fluid coolers shall be readily accessible. Where located on roofs, such equipment having combustible exterior surfaces shall be protected with an approved automatic fire-extinguishing system.

1120.0 Support and Anchorage.  
1120.1 General. Cooling towers, evaporative condensers, and fluid coolers shall be supported on noncombustible grillage designed in accordance with the building code. Seismic restraints shall be as required by the building code.

1121.0 Drainage.  
1121.1 General. Drains, overflows, and blow-down provisions shall have an indirect connection to an approved disposal location. Discharge of chemical waste shall be as approved by the regulatory authority.

1122.0 Chemical Treatment Systems.  
1122.1 General. Chemical treatment systems shall comply with the fire code. Where chemicals used present a contact hazard to personnel, approved emergency eye-wash and shower facilities shall be installed.

1122.2 Automated Control of Cycles of Concentration. Cooling towers, evaporative condensers, and fluid coolers shall include controls that automate system bleed based on conductivity, fraction of metered makeup volume, metered bleed volume, recirculating pump run time, or bleed time.

1123.0 Location.  
1123.1 General. Cooling towers, evaporative condensers, and fluid coolers shall be located such that their plumes cannot enter occupied spaces. Plume discharges shall be not less than 25 feet (7620 mm) away from a ventilation inlet to a building. Location on the property shall be as required for buildings by the building code.

1124.0 Electrical.  
1124.1 General. Electrical systems shall be in accordance with the electrical code. Equipment shall be provided with a vibration switch to shut off fans operating with excessive vibration. In climates commonly subject to electrical storms, lightning protection shall be provided on roof-mounted equipment.
1125.0 Refrigerants and Hazardous Fluids.
1125.1 General. Equipment containing refrigerants as a part of a closed-cycle refrigeration system shall comply with Part I of this chapter. Equipment containing other fluids that are flammable, combustible, or hazardous shall be in accordance with this code and the fire code.

1126.0 Drift Eliminators.
1126.1 General. Cooling towers, evaporative condensers, and fluid coolers shall be equipped with drift eliminators that have a drift rate of not more than 0.005 percent of the circulated water flow rate in accordance with the equipment manufacturer’s instructions.
<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME¹ (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP⁷</th>
<th>OEL² (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-11</td>
<td>CCl₃F</td>
<td>Trichlorofluoromethane</td>
<td>A1</td>
<td>C1000</td>
<td>0.39</td>
</tr>
<tr>
<td>R-12</td>
<td>CCl₂F₂</td>
<td>Dichlorodifluoromethane</td>
<td>A1</td>
<td>1000</td>
<td>5.6</td>
</tr>
<tr>
<td>R-12B1</td>
<td>CBrClF₂</td>
<td>Bromochlorodifluoromethane</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-13</td>
<td>CCIF₃</td>
<td>Chlorotrifluoromethane</td>
<td>A1</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>R-13B1</td>
<td>CBrF₃</td>
<td>Bromotrifluoromethane</td>
<td>A1</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>R-14</td>
<td>CF₄</td>
<td>Tetrafluoromethane (carbon tetrafluoride)</td>
<td>A1</td>
<td>1000</td>
<td>25</td>
</tr>
<tr>
<td>R-21</td>
<td>CHCl₂F</td>
<td>Dichlorodifluoromethane</td>
<td>B1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-22</td>
<td>CHClF₂</td>
<td>Chlorodifluoromethane</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-23</td>
<td>CHF₃</td>
<td>Trifluoromethane</td>
<td>A1</td>
<td>1000</td>
<td>7.3</td>
</tr>
<tr>
<td>R-30</td>
<td>CH₂Cl₂</td>
<td>Dichloromethane (methylene chloride)</td>
<td>B1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-31</td>
<td>CH₂ClF</td>
<td>Chlorofluoromethane</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-32</td>
<td>CH₂F₂</td>
<td>Difluoromethane (methylene fluoride)</td>
<td>A2L</td>
<td>1000</td>
<td>4.8</td>
</tr>
<tr>
<td>R-40</td>
<td>CH₃Cl</td>
<td>Chloromethane (methyl chloride)</td>
<td>B2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-41</td>
<td>CH₃F</td>
<td>Fluoromethane (methyl fluoride)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-50</td>
<td>CH₄</td>
<td>Methane</td>
<td>A3</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>R-113</td>
<td>CCl₂FCCIF₂</td>
<td>1, 1, 2-trichloro-1, 2, 2 - trifluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>1.2</td>
</tr>
<tr>
<td>R-114</td>
<td>CCIF₃CCIF₂</td>
<td>1, 2-dichloro-1, 1, 2, 2 tetrafluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>8.7</td>
</tr>
<tr>
<td>R-115</td>
<td>CCIF₂CF₃</td>
<td>Chloropentafluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>47</td>
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<tr>
<td>R-116</td>
<td>CF₃CF₃</td>
<td>Hexafluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>34</td>
</tr>
<tr>
<td>R-123</td>
<td>CHCl₂CF₃</td>
<td>2, 2-dichloro-1, 1, 1, - trifluoroethane</td>
<td>B1</td>
<td>50</td>
<td>3.5</td>
</tr>
<tr>
<td>R-124</td>
<td>CHClF₃CF₃</td>
<td>2-chloro-1, 1, 1, 2 - tetrafluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>3.5</td>
</tr>
<tr>
<td>R-125</td>
<td>CHF₂CF₃</td>
<td>Pentfluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>23</td>
</tr>
<tr>
<td>R-134a</td>
<td>CH₂FCF₃</td>
<td>1, 1, 1, 2-tetrafluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-141b</td>
<td>CH₃CClF₂</td>
<td>1, 1-dichloro-1-fluoroethane</td>
<td>—</td>
<td>500</td>
<td>0.78</td>
</tr>
<tr>
<td>R-142b</td>
<td>CH₃CCIF₂</td>
<td>1-chloro-1, 1-difluoroethane</td>
<td>A2</td>
<td>1000</td>
<td>5.1</td>
</tr>
<tr>
<td>R-143a</td>
<td>CH₃CF₃</td>
<td>1, 1, 1-trifluoroethane</td>
<td>A2L</td>
<td>1000</td>
<td>4.5</td>
</tr>
<tr>
<td>R-152a</td>
<td>CH₃CHF₂</td>
<td>1, 1-difluoroethane</td>
<td>A2</td>
<td>1000</td>
<td>2.0</td>
</tr>
<tr>
<td>R-170</td>
<td>CH₃CH₃</td>
<td>Ethane</td>
<td>A3</td>
<td>1000</td>
<td>0.54</td>
</tr>
<tr>
<td>R-E170</td>
<td>CH₃OCH₃</td>
<td>Methoxymethane (Dimethyl ether)</td>
<td>A3</td>
<td>1000</td>
<td>1.0</td>
</tr>
<tr>
<td>R-218</td>
<td>CF₃CF₂CF₃</td>
<td>Octafluoropropane</td>
<td>A1</td>
<td>1000</td>
<td>43</td>
</tr>
<tr>
<td>R-227ea</td>
<td>CF₃CHFCF₃</td>
<td>1, 1, 1, 2, 3, 3, 3- heptafluoropropane</td>
<td>A1</td>
<td>1000</td>
<td>36</td>
</tr>
<tr>
<td>R-236fa</td>
<td>CF₃CH₂CF₃</td>
<td>1, 1, 1, 3, 3, 3-hexafluoropropane</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-245fa</td>
<td>CHF₂CH₂CF₃</td>
<td>1, 1, 1, 3, 3-pentafluoropropane</td>
<td>B1</td>
<td>300</td>
<td>12</td>
</tr>
<tr>
<td>R-290</td>
<td>CH₃CH₂CH₃</td>
<td>Propane</td>
<td>A3</td>
<td>1000</td>
<td>0.56</td>
</tr>
<tr>
<td>R-318</td>
<td>-(CF₂)₄</td>
<td>Octafluorocyclobutane</td>
<td>A1</td>
<td>1000</td>
<td>41</td>
</tr>
<tr>
<td>R-400</td>
<td>zeotrope</td>
<td>R-12/114 (50.0/50.0)</td>
<td>A1</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>R-400</td>
<td>zeotrope</td>
<td>R-12/114 (60.0/40.0)</td>
<td>A1</td>
<td>1000</td>
<td>11</td>
</tr>
<tr>
<td>R-401A</td>
<td>zeotrope</td>
<td>R-22/152a/124 (53.0/13.0/34.0)</td>
<td>A1</td>
<td>1000</td>
<td>6.6</td>
</tr>
<tr>
<td>R-401B</td>
<td>zeotrope</td>
<td>R-22/152a/124 (61.0/11.0/28.0)</td>
<td>A1</td>
<td>1000</td>
<td>7.2</td>
</tr>
<tr>
<td>R-401C</td>
<td>zeotrope</td>
<td>R-22/152a/124 (33.0/15.0/52.0)</td>
<td>A1</td>
<td>1000</td>
<td>5.2</td>
</tr>
<tr>
<td>R-402A</td>
<td>zeotrope</td>
<td>R-125/290/22 (60.0/2.0/38.0)</td>
<td>A1</td>
<td>1000</td>
<td>17</td>
</tr>
</tbody>
</table>

¹ COMPOSITION FOR BLENDS
² OEL (ppm) ³ POUNDS PER 1000 CUBIC FEET OF SPACE
⁴ ASHRAE 34: TABLE 4-1, TABLE 4-2
⁵ TABLE 1102.3

REFRIGERATION

178  UNIFORM MECHANICAL CODE - PREPRINT
# Table 1102.3 (continued)

**Refrigerant Groups, Properties, and Allowable Quantities**

[[ASHRAE 34: Table 4-1, Table 4-2]]

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Chemical Formula</th>
<th>Chemical Name¹</th>
<th>Safety Group²</th>
<th>OEL³ (ppm)</th>
<th>Pounds per 1000 Cubic Feet of Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-402B</td>
<td>zeotrope</td>
<td>R-125/290/22 (38.0/2.0/60.0)</td>
<td>A1</td>
<td>1000</td>
<td>15</td>
</tr>
<tr>
<td>R-403A</td>
<td>zeotrope</td>
<td>R-290/22/218 (5.0/75.0/20.0)</td>
<td>A2</td>
<td>1000</td>
<td>7.6</td>
</tr>
<tr>
<td>R-403B</td>
<td>zeotrope</td>
<td>R-290/22/218 (5.0/56.0/39.0)</td>
<td>A1</td>
<td>1000</td>
<td>18</td>
</tr>
<tr>
<td>R-404A</td>
<td>zeotrope</td>
<td>R-125/134a/134a (44.0/52.0/4.0)</td>
<td>A1</td>
<td>1000</td>
<td>31</td>
</tr>
<tr>
<td>R-405A</td>
<td>zeotrope</td>
<td>R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)</td>
<td>—</td>
<td>1000</td>
<td>16</td>
</tr>
<tr>
<td>R-406A</td>
<td>zeotrope</td>
<td>R-22/600a/142b (55.0/4.0/41.0)</td>
<td>A2</td>
<td>1000</td>
<td>4.7</td>
</tr>
<tr>
<td>R-407A</td>
<td>zeotrope</td>
<td>R-32/125/134a (20.0/40.0/40.0)</td>
<td>A1</td>
<td>1000</td>
<td>19</td>
</tr>
<tr>
<td>R-407B</td>
<td>zeotrope</td>
<td>R-32/125/134a (10.0/70.0/20.0)</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-407C</td>
<td>zeotrope</td>
<td>R-32/125/134a (23.0/25.0/52.0)</td>
<td>A1</td>
<td>1000</td>
<td>18</td>
</tr>
<tr>
<td>R-407D</td>
<td>zeotrope</td>
<td>R-32/125/134a (15.0/15.0/70.0)</td>
<td>A1</td>
<td>1000</td>
<td>16</td>
</tr>
<tr>
<td>R-407E</td>
<td>zeotrope</td>
<td>R-32/125/134a (25.0/15.0/60.0)</td>
<td>A1</td>
<td>1000</td>
<td>17</td>
</tr>
<tr>
<td>R-407F</td>
<td>zeotrope</td>
<td>R-32/125/134a (30.0/30.0/40.0)</td>
<td>A1</td>
<td>1000</td>
<td>20</td>
</tr>
<tr>
<td>R-407G</td>
<td>zeotrope</td>
<td>R-32/125/134a (2.5/2.5/95.0)</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-407H</td>
<td>zeotrope</td>
<td>R-32/125/134a (32.5/15.0/52.5)</td>
<td>A1</td>
<td>1000</td>
<td>19</td>
</tr>
<tr>
<td>R-407I</td>
<td>zeotrope</td>
<td>R-32/125/124a (19.5/8.5/72.0)</td>
<td>A1</td>
<td>1000</td>
<td>16.0</td>
</tr>
<tr>
<td>R-408A</td>
<td>zeotrope</td>
<td>R-125/143a/22 (7.0/46.0/47.0)</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-409A</td>
<td>zeotrope</td>
<td>R-22/124/142b (60.0/25.0/15.0)</td>
<td>A1</td>
<td>1000</td>
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</tr>
<tr>
<td>R-409B</td>
<td>zeotrope</td>
<td>R-22/124/142b (65.0/25.0/10.0)</td>
<td>A1</td>
<td>1000</td>
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<tr>
<td>R-410A</td>
<td>zeotrope</td>
<td>R-32/125 (50.0/50.0)</td>
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<tr>
<td>R-410B</td>
<td>zeotrope</td>
<td>R-32/125 (45.0/55.0)</td>
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<td>R-411A</td>
<td>zeotrope</td>
<td>R-1270/22/152a (1.5/87.5/11.0)</td>
<td>A2</td>
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<td>2.9</td>
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<tr>
<td>R-411B</td>
<td>zeotrope</td>
<td>R-1270/22/152a (3.0/94.0/3.0)</td>
<td>A2</td>
<td>980</td>
<td>2.8</td>
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<tr>
<td>R-412A</td>
<td>zeotrope</td>
<td>R-22/218/142b (70.0/5.0/25.0)</td>
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<td>R-218/134a/600a (9.0/88.0/3.0)</td>
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<td>zeotrope</td>
<td>R-22/124/600a/142b (51.0/28.5/4.0/16.5)</td>
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<td>R-22/124/600a/142b (50.0/39.0/1.5/9.5)</td>
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<td>R-415A</td>
<td>zeotrope</td>
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<td>R-417C</td>
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<td>R-125/134a/600 (19.5/78.8/1.7)</td>
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<td>1000</td>
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<td>R-418A</td>
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<td>1000</td>
<td>4.8</td>
</tr>
<tr>
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<td>R-125/134a/E170 (77.0/19.0/4.0)</td>
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<td>4.2</td>
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<td>R-125/134a/E170 (48.5/48.0/3.5)</td>
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<td>R-134a/142b (88.0/12.0)</td>
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<td>R-421A</td>
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<td>zeotrope</td>
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<td>R-422D</td>
<td>zeotrope</td>
<td>R-125/134a/600a (65.1/31.5/3.4)</td>
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<tr>
<td>R-423A</td>
<td>zeotrope</td>
<td>R-134a/227ea (52.5/47.5)</td>
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<td>R-424A</td>
<td>zeotrope</td>
<td>R-125/134a/600a/600/601a (50.5/47.0/9.1/0.6)</td>
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<td>zeotrope</td>
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<td>A1</td>
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</tr>
<tr>
<td>REFRIGERANT</td>
<td>CHEMICAL FORMULA</td>
<td>CHEMICAL NAME (^1) (COMPOSITION FOR BLENDS)</td>
<td>SAFETY GROUP (^2)</td>
<td>OEL (^2) (ppm)</td>
<td>POUNDS PER 1000 CUBIC FEET OF SPACE</td>
</tr>
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<td>R-426A (^6)</td>
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<td>R-125/134a/600/601a (5.1/93.0/1.3/0.6)</td>
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<td>990</td>
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<tr>
<td>R-427A</td>
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<td>1000</td>
<td>18</td>
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<td>R-428A</td>
<td>zeotrope</td>
<td>R-125/143a/290/600a (77.5/20.0/0.6/1.9)</td>
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<td>1000</td>
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<tr>
<td>R-429A</td>
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<td>R-E170/152a/600a (60.0/10.0/30.0)</td>
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<td>R-430A</td>
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<td>R-152a/600a (76.0/24.0)</td>
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<td>1000</td>
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<td>R-431A</td>
<td>zeotrope</td>
<td>R-290/152a (71.0/29.0)</td>
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<td>zeotrope</td>
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<td>A1</td>
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<td>5.0</td>
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<tr>
<td>R-433A</td>
<td>zeotrope</td>
<td>R-32/125/134a/600/601a (8.5/45.0/44.2/1.7/0.6)</td>
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<tr>
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<td>zeotrope</td>
<td>R-125/134a/600/601a (85.4/45.0/44.2/1.7/0.6)</td>
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<td>R-E170/152a (80.0/20.0)</td>
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<td>R-436A</td>
<td>zeotrope</td>
<td>R-290/600a (56.0/44.0)</td>
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<tr>
<td>R-436B</td>
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<td>R-125/134a/600/601a (19.5/78.5/1.4/0.6)</td>
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<td>5.0</td>
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<td>R-438A</td>
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<td>R-32/125/134a/600/601a (85.4/45.0/44.2/1.7/0.6)</td>
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<td>990</td>
<td>4.9</td>
</tr>
<tr>
<td>R-439A</td>
<td>zeotrope</td>
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<td>A2</td>
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<td>4.7</td>
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<td>R-440A</td>
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<td>R-290/134a/152a (0.6/1.6/97.8)</td>
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<td>1.9</td>
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<td>R-441A</td>
<td>zeotrope</td>
<td>R-170/290/600a (31.0/54.8/6.0/36.1)</td>
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<td>R-32/125/134a/600/601a (20.0/20.0/53.8/5.0/0.6)</td>
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<td>R-443A</td>
<td>zeotrope</td>
<td>R-1270/290/600a (55.0/40.0/50.0)</td>
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<td>R-444A</td>
<td>zeotrope</td>
<td>R-32/125/600a (50.0/47.0/3.0)</td>
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<td>5.1</td>
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<td>zeotrope</td>
<td>R-32/125/600a (50.0/47.0/3.0)</td>
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<td>4.3</td>
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<tr>
<td>R-445A</td>
<td>zeotrope</td>
<td>R-744/134a/227a (E) (41.5/10.0/48.5)</td>
<td>A2</td>
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<td>4.2</td>
</tr>
<tr>
<td>R-446A</td>
<td>zeotrope</td>
<td>R-32/1234ze(E)/600 (68.0/29.0/3.0)</td>
<td>A2</td>
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<td>2.5</td>
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<tr>
<td>R-447A</td>
<td>zeotrope</td>
<td>R-32/1234ze(E) (68.0/3.5/28.5)</td>
<td>A2</td>
<td>900</td>
<td>2.6</td>
</tr>
<tr>
<td>R-447B</td>
<td>zeotrope</td>
<td>R-32/1234ze(E) (68.0/8.0/24.0)</td>
<td>A2</td>
<td>970</td>
<td>2.3</td>
</tr>
<tr>
<td>R-448A</td>
<td>zeotrope</td>
<td>R-32/1234yf/134a/227a (E) (26.0/26.0/20.0/21.0/7.0)</td>
<td>A1</td>
<td>890</td>
<td>24</td>
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<tr>
<td>R-449A</td>
<td>zeotrope</td>
<td>R-32/1234yf/134a/227a (E) (26.0/26.0/20.0/21.0/7.0)</td>
<td>A1</td>
<td>890</td>
<td>24</td>
</tr>
<tr>
<td>R-449B</td>
<td>zeotrope</td>
<td>R-32/1234yf/134a/227a (E) (26.0/26.0/20.0/21.0/7.0)</td>
<td>A1</td>
<td>890</td>
<td>24</td>
</tr>
<tr>
<td>R-449C</td>
<td>zeotrope</td>
<td>R-32/1234yf/134a/227a (E) (26.0/26.0/20.0/21.0/7.0)</td>
<td>A1</td>
<td>890</td>
<td>24</td>
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<td>zeotrope</td>
<td>R-134a/1234ze(E) (42.0/58.0)</td>
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<td>R-451A</td>
<td>zeotrope</td>
<td>R-1234yf/134a (89.8/10.2)</td>
<td>A2L</td>
<td>520</td>
<td>5.3</td>
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<td>zeotrope</td>
<td>R-1234yf/134a (89.8/10.2)</td>
<td>A2L</td>
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<td>R-32/125/1234yf (11.0/59.0/30.0)</td>
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<td>R-452B</td>
<td>zeotrope</td>
<td>R-32/125/1234yf (67.0/7.0/26.0)</td>
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<td>870</td>
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<tr>
<td>R-452C</td>
<td>zeotrope</td>
<td>R-32/125/1234yf (12.5/61.0/26.5)</td>
<td>A1</td>
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<td>27</td>
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<tr>
<td>R-453A</td>
<td>zeotrope</td>
<td>R-32/125/1234yf/134a/227a (E) (26.0/26.0/20.0/21.0/7.0)</td>
<td>A1</td>
<td>1000</td>
<td>7.8</td>
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<td>R-32/1234yf (35.0/65.0)</td>
<td>A2L</td>
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<td>28</td>
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<tr>
<td>R-454B</td>
<td>zeotrope</td>
<td>R-32/1234yf (68.9/31.1)</td>
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<td>620</td>
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### TABLE 1102.3 (continued)

**REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES**

[ASHRAE 34: TABLE 4-1, TABLE 4-2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME(^1) (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP(^2)</th>
<th>OEL(^2) (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-455A</td>
<td>zeotrope</td>
<td>R-744/32/1234yf (3.0/21.5/75.5)</td>
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<td>zeotrope</td>
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<td>R-32/1234yf/1234ze(E) (68.1/26.0/6.0)</td>
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<td>23</td>
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<td>R-32/1234yf/1234ze(E) (21.0/69.0/10.0)</td>
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<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (12.0/52.0/14.0/22.0)</td>
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<td>zeotrope</td>
<td>R-32/125/134a/1234ze(E) (28.0/25.0/20.0/7.0)</td>
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<td>zeotrope</td>
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<td>1000</td>
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<td>zeotrope</td>
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<td>azo trope(^3)</td>
<td>R-12/152a (73.8/26.2)</td>
<td>A1</td>
<td>1000</td>
<td>7.6</td>
</tr>
<tr>
<td>R-501</td>
<td>azo trope(^3)</td>
<td>R-22/12 (75.0/25.0)(^4)</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-502</td>
<td>azo trope(^3)</td>
<td>R-22/115 (48.8/51.2)</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-503</td>
<td>azo trope(^3)</td>
<td>R-23/13 (40.1/59.9)</td>
<td>—</td>
<td>1000</td>
<td>—</td>
</tr>
<tr>
<td>R-504</td>
<td>azo trope(^3)</td>
<td>R-32/115 (48.2/51.8)</td>
<td>—</td>
<td>1000</td>
<td>28</td>
</tr>
<tr>
<td>R-505</td>
<td>azo trope(^3)</td>
<td>R-12/31 (78.0/22.0)(^4)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-506</td>
<td>azo trope(^3)</td>
<td>R-31/114 (55.1/44.9)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-507A</td>
<td>azo trope(^3)</td>
<td>R-125/134a (50.0/50.0)</td>
<td>A1</td>
<td>1000</td>
<td>32</td>
</tr>
<tr>
<td>R-508A</td>
<td>azo trope(^3)</td>
<td>R-23/116 (39.0/61.0)</td>
<td>A1</td>
<td>1000</td>
<td>14</td>
</tr>
<tr>
<td>R-508B</td>
<td>azo trope(^3)</td>
<td>R-23/116 (46.0/54.0)</td>
<td>A1</td>
<td>1000</td>
<td>13</td>
</tr>
<tr>
<td>R-509A</td>
<td>azo trope(^3)</td>
<td>R-22/218 (44.0/56.0)</td>
<td>A1</td>
<td>1000</td>
<td>24</td>
</tr>
<tr>
<td>R-510A</td>
<td>azo trope(^3)</td>
<td>R-170/600a (88.0/12.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.87</td>
</tr>
<tr>
<td>R-511A</td>
<td>azo trope(^3)</td>
<td>R-290/170 (95.0/5.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.59</td>
</tr>
<tr>
<td>R-512A</td>
<td>azo trope(^3)</td>
<td>R-134a/152a (5.0/95.0)</td>
<td>A2</td>
<td>1000</td>
<td>1.9</td>
</tr>
<tr>
<td>R-513A</td>
<td>azo trope(^3)</td>
<td>R-1234yf/134a (56.0/44.0)</td>
<td>A1</td>
<td>650</td>
<td>20</td>
</tr>
<tr>
<td>R-513B</td>
<td>azo trope(^3)</td>
<td>R-1234yf/134a (58.5/41.5)</td>
<td>A1</td>
<td>640</td>
<td>21</td>
</tr>
<tr>
<td>R-514A</td>
<td>azo trope(^3)</td>
<td>R-1336mzz(Z)/1130 (E) (74.7/25.3)</td>
<td>B1</td>
<td>320</td>
<td>0.86</td>
</tr>
<tr>
<td>R-515A</td>
<td>azo trope(^3)</td>
<td>R-1234ze(E)/227ea (88.0/12.0)</td>
<td>A1</td>
<td>810</td>
<td>19</td>
</tr>
<tr>
<td>R-516A</td>
<td>azo trope(^3)</td>
<td>R-1234yf/134a/152a (77.5/8.5/14.0)</td>
<td>A2L</td>
<td>590</td>
<td>7.0</td>
</tr>
<tr>
<td>R-600</td>
<td>CH₃CH₂CH₂CH₃</td>
<td>Butane</td>
<td>A3</td>
<td>1000</td>
<td>0.15</td>
</tr>
<tr>
<td>R-600a</td>
<td>CH(CH₃)₂CH₃</td>
<td>2-methylpropane (isobutene)</td>
<td>A3</td>
<td>1000</td>
<td>0.59</td>
</tr>
<tr>
<td>R-601</td>
<td>CH₃CH₂CH₂CH₂CH₂CH₃</td>
<td>Pentane</td>
<td>A3</td>
<td>600</td>
<td>0.18</td>
</tr>
</tbody>
</table>
### TABLE 1102.3 (continued)
#### REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES

[ASHRAE 34: TABLE 4-1, TABLE 4-2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME¹ (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP²</th>
<th>OEL³ (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-601a</td>
<td>(CH₃)₂CHCH₂CH₃</td>
<td>2-methylbutane (isopentane)</td>
<td>A₃</td>
<td>600</td>
<td>0.18</td>
</tr>
<tr>
<td>R-610</td>
<td>CH₃CH₂OCH₂CH₃</td>
<td>Ethoxyethane (ethyl ether)</td>
<td>—</td>
<td>400</td>
<td>—</td>
</tr>
<tr>
<td>R-611</td>
<td>HCOOCH₃</td>
<td>Methyl formate</td>
<td>B₂</td>
<td>100</td>
<td>—</td>
</tr>
<tr>
<td>R-620</td>
<td>—</td>
<td>(Reserved for future assignment)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-630</td>
<td>CH₃NH₂</td>
<td>Methanamine (methyl amine)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-631</td>
<td>CH₃CH₂(NH₂)</td>
<td>Ethanamine (ethyl amine)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-702</td>
<td>H₂</td>
<td>Hydrogen</td>
<td>A₃</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-704</td>
<td>He</td>
<td>Helium</td>
<td>A₁</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-717</td>
<td>NH₃</td>
<td>Ammonia</td>
<td>B₂L</td>
<td>25</td>
<td>0.014</td>
</tr>
<tr>
<td>R-718</td>
<td>H₂O</td>
<td>Water</td>
<td>A₁</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-720</td>
<td>Ne</td>
<td>Neon</td>
<td>A₁</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-728</td>
<td>N₂</td>
<td>Nitrogen</td>
<td>A₁</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-732</td>
<td>O₂</td>
<td>Oxygen</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-740</td>
<td>Ar</td>
<td>Argon</td>
<td>A₁</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-744</td>
<td>CO₂</td>
<td>Carbon dioxide</td>
<td>A₁</td>
<td>5000</td>
<td>3.4</td>
</tr>
<tr>
<td>R-744A</td>
<td>N₂O</td>
<td>Nitrous oxide</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-764</td>
<td>SO₂</td>
<td>Sulfur dioxide</td>
<td>B₁</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>R-1130(E)</td>
<td>CHCl=CHCl</td>
<td>Trans-1,2-dichloroethene</td>
<td>B₁</td>
<td>200</td>
<td>0.25</td>
</tr>
<tr>
<td>R-1132a</td>
<td>CF₂ = CH₂</td>
<td>1, 1-difluoroethylene</td>
<td>A₂</td>
<td>500</td>
<td>2.0</td>
</tr>
<tr>
<td>R-1150</td>
<td>CH₂=CH₂</td>
<td>Ethene (ethylene)</td>
<td>A₃</td>
<td>200</td>
<td>—</td>
</tr>
<tr>
<td>R-1224zd(Z)</td>
<td>CF₂CF=CHCl</td>
<td>(Z)-1-chloro-2,3,3,3-tetrafluoropropen</td>
<td>A₁</td>
<td>1000</td>
<td>23</td>
</tr>
<tr>
<td>R-1233zd(E)</td>
<td>CF₂CH=CHCl</td>
<td>Trans-1-chloro-2,3,3,3-tetrafluoro-1- propene</td>
<td>A₁</td>
<td>800</td>
<td>5.3</td>
</tr>
<tr>
<td>R-1234yf</td>
<td>CF₃CF=CH₂</td>
<td>2, 3, 3, 3-tetrafluoro-1-propene</td>
<td>A₂L</td>
<td>500</td>
<td>4.7</td>
</tr>
<tr>
<td>R-1234ze(E)</td>
<td>CF₃CH=CHF</td>
<td>Trans-1,3,3,3-tetrafluoro-1-propene</td>
<td>A₂L</td>
<td>800</td>
<td>4.7</td>
</tr>
<tr>
<td>R-1270</td>
<td>CH₃CH=CH₂</td>
<td>Propene (propylene)</td>
<td>A₃</td>
<td>500</td>
<td>0.11</td>
</tr>
<tr>
<td>1336mzz(Z)</td>
<td>CF₃CH CHCF₃</td>
<td>Cis-1,1,1,4,4,4-hexafluoro-2-butene</td>
<td>A₁</td>
<td>500</td>
<td>5.4</td>
</tr>
</tbody>
</table>

For SI units: 1 pound = 0.453 kg, 1 cubic foot = 0.0283 m³

**Notes:**

1. The preferred chemical name is followed by the popular name in parenthesis.
2. The OELs are 8-hour TWAs; a “C” designation denotes a ceiling limit.
3. Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated. The extent of segregation depends on the particular azeotrope and hardware system configuration.
4. The exact composition of this azeotrope is in question and additional experimental studies are needed.
5. R-507, R-508, and R-509 are allowed alternative designations for R-507A, R-508A, and R-509A due to a change in designations after assignment of R-500 through R-509. Corresponding changes were not made for R-500 through R-506.
6. The RCL values for these refrigerant blends are approximated in the absence of adequate data for a component comprising less than 4 percent m/m of the blend and expected to have a small influence in an acute, accidental release.
7. Refrigerant flammability classification of Class 2L shall comply with the requirements for flammability classification of Class 2.
8. In accordance with Section 1102.2, ammonia refrigeration systems are not regulated by this chapter. R-717 (ammonia) is included in this table because the table is extracted from ASHRAE 34 and is not capable of being modified.
### TABLE 1104.1
PERMISSIBLE REFRIGERATION SYSTEMS\(^1\)

<table>
<thead>
<tr>
<th>OCCUPANCY GROUP*</th>
<th>HIGH-PROBABILITY SYSTEM</th>
<th>LOW PROBABILITY SYSTEM</th>
<th>MACHINERY ROOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>A-2</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>A-3</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>A-4</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>B</td>
<td>Group A1(^2) only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>E</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>F-1</td>
<td>Group A1(^2) only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>F-2</td>
<td>Any(^2)</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-1</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-2</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-3</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-4</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>H-5</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-1</td>
<td>None</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-2</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-3</td>
<td>None</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-4</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>M</td>
<td>Group A1(^1) only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>R-1</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>R-2</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>R-3</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>R-4</td>
<td>Group A1 only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>S-1</td>
<td>Group A1(^2) only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>S-2</td>
<td>Any(^2)</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>U</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
</tr>
</tbody>
</table>

**Notes:**

\(^1\) See Section 1104.0.

\(^2\) A refrigerant shall be permitted to be used within a high-probability system where the room or space is in accordance with Section 1104.4.

\(^3\) Occupancy classifications are defined in the building code.
CHAPTER 12
HYDRONICS

1201.0 General.
1201.1 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, chilled water, steam condensate, condenser water, and ground source heat pump systems. The regulations of this chapter shall govern the construction, location, and installation of hydronic piping systems.

1201.2 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.

1201.3 Water Hammer. The piping system shall be designed to prevent water hammer.

1201.4 Terminal Units. Terminal units, valves, and flow control devices shall be installed in accordance with the manufacturer’s installation instructions.

1201.5 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.

1202.0 Protection of Potable Water Supply.
1202.1 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.

1202.2 Chemical Injection. Where systems include an additive, chemical injection or provisions for such injection, the potable water supply shall be protected by a reduced-pressure principle backflow prevention assembly listed or labeled in accordance with ASSE 1013. Such additive or chemical shall be compatible with system components.

1202.3 Compatibility. Fluids used in hydronic systems shall be compatible with all components that will contact the fluid. Where a heat exchanger is installed with a dual purpose water heater, such application shall comply with the requirements for a single wall heat exchanger in Section 1218.1.

1203.0 Capacity of Heat Source.
1203.1 Heat Source. The heat source shall be sized to the design load.

1203.2 Dual Purpose Water Heater. Water heaters utilized for combined space-heating and water-heating applications shall be listed or labeled in accordance with the standards referenced in Table 1203.2, and shall be installed in accordance with the manufacturer’s installation instructions. The total heating capacity of a dual purpose water heater shall be based on the sum of the potable hot water requirements and the space heating design requirements corrected for hot water first-hour draw recovery.

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

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

1203.3 Tankless Water Heater. Tankless water heaters 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. Manufacturers flow rates shall not be exceeded.

1204.0 Identification of a Potable and Nonpotable Water System.
1204.1 General. In buildings where potable water and nonpotable water systems are installed, each system shall be clearly identified in accordance with Section 1204.2 through Section 1204.5.

1204.2 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.

1204.3 Potable Water. Potable water systems shall be identified with a green background with white lettering. The minimum size of letters and length of the color field shall be in accordance with Table 1204.3.

1204.4 Nonpotable Water. Nonpotable water systems shall have a yellow background with black uppercase lettering, with the words “CAUTION: NONPOTABLE WATER, DO NOT DRINK.” Each nonpotable system shall be identified to designate 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 1204.3.

<table>
<thead>
<tr>
<th>OUTSIDE DIAMETER OF PIPE OR COVERING (inches)</th>
<th>MINIMUM LENGTH OF COLOR FIELD (inches)</th>
<th>MINIMUM SIZE OF LETTERS (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 to 1 1/4</td>
<td>8</td>
<td>1/2</td>
</tr>
<tr>
<td>1 1/2 to 2</td>
<td>8</td>
<td>1/4</td>
</tr>
<tr>
<td>2 1/2 to 6</td>
<td>12</td>
<td>1 1/4</td>
</tr>
<tr>
<td>8 to 10</td>
<td>24</td>
<td>2 1/2</td>
</tr>
<tr>
<td>over 10</td>
<td>32</td>
<td>3 1/2</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

1204.5 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.

1204.6 Flow Directions. Flow directions shall be indicated on the system.

1205.0 Installation, Testing, and Inspection.

1205.1 Operating Instructions. Operating and maintenance information shall be provided to the building owner.

1205.2 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.

Exception: 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.

1205.3 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.

1206.0 Pressure and Safety Devices.

1206.1 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.

1206.2 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. Equal to 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.
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.

1207.3 Dual-Purpose Water Heaters. Water heaters used for combined space- and water-heating applications shall be in accordance with the standards referenced in Table 1203.2, 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 system to a temperature of 140°F (60°C) or less.
1207.4 Solar Heat Collector Systems. Solar water heating systems used in hydronic panel radiant heating systems shall be installed in accordance with the Uniform Solar Energy Code and Hydronics Code (USEHC).

1208.0 Circulators and Pumps.
1208.1 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.

1208.2 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. Where means for controlling vibration of a circulator or pump is required, an approved means for support and restraint shall be provided.

1208.3 Sizing. The selection and sizing of a circulator or pump shall be based on all of 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 per square inch (kPa)
5. Fluid type

1209.0 Expansion Tanks.
1209.1 General. An expansion tank shall be installed in each closed hydronic system to control system pressure due to thermal expansion and contraction. Expansion tanks shall be of the closed or open type. Expansion tanks shall be rated for the pressure of the system.

1209.2 Installation. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating-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 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.

1209.3 Open-Type Expansion Tanks. Open type expansion tanks shall be located not less than 3 feet (914 mm) above the highest point of the system. An overflow with a diameter of not less than one-half the size of the supply or not less than 1 inch (25 mm) in diameter shall be installed at the top of the tank. The overflow shall discharge through an air gap into the drainage system.

1209.4 Closed-Type 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.

1209.5 Sizing. Expansion tanks shall be sized to accept the full expansion volume of the fluid in the system. The minimum capacity of a closed-type expansion tank shall be sized in accordance with Section 1004.4.

1210.0 Materials.
1210.1 Piping, Tubing, and Fittings. Hydronic pipe and tubing shall comply with the applicable standards referenced in Table 1210.1 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 compatible 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 1210.1. Where required, exterior piping shall be protected against freezing, UV radiation, corrosion and degradation. Embedded pipe or tubing shall comply with Section 1221.2.

1210.2 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.

1210.3 Hangers and Supports. Pipe and tubing shall be supported in accordance with Section 313.3. Equipment that is part of the piping system shall be provided with additional support in accordance with this code and manufacturer’s installation instructions.

1210.4 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.

1210.5 Location. Piping and tubing shall be supported in accordance with Section 313.3.

1211.0 Joints and Connections.
1211.1 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. Pipe bends shall have a radius of not less than six times the outside diameter of the tubing or shall be in accordance with the manufacturer’s installation instructions. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1211.2 Chlorinated Polyvinyl Chloride (CPVC) Pipe. Joints between chlorinated polyvinyl chloride (CPVC) pipe or fittings shall be installed in accordance with one of the following methods:
### Mechanical Joints

Mechanical joints shall include flanged, grooved, and push fit fittings. Removable and non-removable push fit fittings with an elastomeric o-ring that employ quick assembly push fit connectors shall be in accordance with ASSE 1061.

### Solvent Cement Joints

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 or red in color, shall be permitted for pipe and fittings manufactured in accordance with ASTM D2846, 1/2 of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, 1/2 of an inch (15 mm) through 3 inches (80 mm) in diameter. Apply primer where required inside the fitting and to the

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#### TABLE 1210.1

MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>PIPING/TUBING</th>
<th>FITTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>ASTM A269, ASTM A312, ASTM A554, ASTM A778</td>
<td>ASTM F1476, ASTM F1548, ASTM F3226, IAPMO PS 117</td>
</tr>
<tr>
<td>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 D2486, ASTM F441, ASTM F442, CSA B137.6</td>
<td>ASSE 1061, ASTM D2486, ASTM F437, ASTM F438, ASTM F439, ASTM F1970, CSA B137.6</td>
</tr>
<tr>
<td>Polypolyethylene (PP)</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
</tr>
<tr>
<td>Raised Temperature Polyethylene (PE-RT)</td>
<td>ASTM F2623, ASTM F2769, CSA B137.18</td>
<td>ASSE 1061, ASTM F1807, ASTM F2159, ASTM F2735, ASTM F2769, ASTM D3261, ASTM F1055, CSA B137.18</td>
</tr>
<tr>
<td>Polyethylene/Aluminum/Polyethylene (PE-AL-PE)</td>
<td>ASTM F1282, CSA B137.9</td>
<td>ASTM F1282, ASTM F1974, CSA B137.9</td>
</tr>
<tr>
<td>Chlorinated Polyvinyl Chloride/Aluminum/Chlorinated Polyvinyl Chloride (CPVC/AL/CPVC)</td>
<td>ASTM F2855</td>
<td>ASTM D2846</td>
</tr>
</tbody>
</table>

**Note:**

1. Ductile and gray iron.
2. Only type K, L, or M tubing allowed to be installed.

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1. Mechanical joints shall include flanged, grooved, and push fit fittings. Removable and non-removable 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 or red in color, shall be permitted for pipe and fittings manufactured in accordance with ASTM D2846, 1/2 of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, 1/2 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.

1211.3 CPVC/AL/CPVC Plastic Pipe and Joints. Joints between chlorinated polyvinyl chloride/aluminum/ chlorinated polyvinyl chloride (CPVC/AL/CPVC) pipe or fittings shall be installed in accordance with one of the following methods:

(1) Mechanical joints shall include flanged and grooved.

(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. Half of an inch (15 mm) through 2 inches (50 mm) in diameter, 1/2 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.

1211.4 Copper or Copper Alloy Pipe and Tubing. Joints between copper or copper alloy pipe, tubing, or fittings shall be installed in accordance with one of the following methods:

(1) Brazed joints between copper or copper alloy pipe, tubing, or fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). The joint surfaces to be brazed shall be cleaned bright by either manual or mechanical means. Tubing shall be cut square and reamed to full inside diameter. Brazing flux shall be applied to the 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.

(2) 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 1210.1. 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.

(3) 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 1/4 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.

(4) Pressed fittings for copper or copper alloy pipe or tubing shall have an elastomeric o-ring that forms the joint. The pipe or tubing shall be fully inserted into the fitting, and the pipe or tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the pipe or tubing to ensure the pipe or tubing is inserted into the fitting. The joint shall be pressed using the tool recommended by the manufacturer.

(5) Removable and nonremovable push fit 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. Pipe or tubing shall be cut square, chamfered, and reamed to full inside diameter. The tubing shall be fully inserted into the fitting, and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to ensure the tubing is inserted into the fitting and gripping mechanism has engaged on the pipe.

(6) Soldered joints between copper or copper alloy pipe, tubing, or fittings shall be made in accordance with ASTM B828. Pipe or tubing shall be cut square and reamed to the full inside diameter including the removal of burrs on the outside of the pipe or tubing. Surfaces to be joined shall be cleaned bright by manual or mechanical means. Flux shall be applied to pipe or tubing and fittings and shall be in accordance with ASTM B813, and shall become noncorrosive and nontoxic after soldering. Insert pipe or tubing into the base of the fitting and remove excess flux. Pipe or tubing and fitting shall be supported to ensure a uniform capillary space around the joint. Solder in accordance with ASTM B32 shall be applied to the joint surfaces until capillary action draws the molten solder into the cup. Joint surfaces shall not be disturbed until cool, and any remaining flux residue shall be cleaned.

(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.

1211.5 Cross-Linked Polyethylene (PEX) Pipe. Joints between cross-linked polyethylene (PEX) pipe or fittings shall be installed with fittings for PEX tubing that comply with the applicable standards referenced in Table 1210.1. PEX tubing labeled in accordance with ASTM F876 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.

1211.6 Cross-Linked Polyethylene/Aluminum/Cross-Linked Polyethylene (PEX-AL-PEX) Pipe. Joints between cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe or fittings shall be installed in accordance with one of the following methods:

1. Mechanical joints between PEX-AL-PEX pipe or 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.

1211.7 Ductile Iron Pipe. Joints between ductile iron pipe or fittings shall be installed in accordance with one of the following methods:

1. Mechanical joints for ductile iron pipe or 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 gasket and the plain end of the pipe or fitting. The elastomeric gasket shall comply with AWWA C111. Lubricant recommended for the application by the pipe manufacturer shall be applied to the gasket and plain end of the pipe.

2. Push-on joints for ductile iron pipe or 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. Lubricant recommended for the application by the pipe manufacturer shall be applied to the gasket and plain end of the pipe.

1211.8 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe, tubing, or fittings shall be installed in accordance with one of the following:

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, tubing, or 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 the 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.

1211.9 Polyethylene/Aluminum/Polyethylene (PE-AL-PE). Joints between polyethylene/aluminum/polyethylene (PE-AL-PE) pipe or fittings shall be installed in accordance with one of the following methods:

1. Mechanical joints for PE-AL-PE pipe, tubing, or 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 1/8 of an inch (3.2 mm) to 1/4 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, tubing, or 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.

**1211.10 Polyethylene of Raised Temperature (PE-RT).** Joints between polyethylene of raised temperature (PE-RT) tubing or fittings shall be installed with fittings for PE-RT tubing that comply with the applicable standards referenced in Table 1210.1. Metal insert fittings, metal compression fittings, and plastic fittings shall be manufactured to and marked in accordance with the standards for fittings in Table 1210.1.

**1211.11 Polypropylene (PP) Pipe.** Joints between polypropylene pipe or 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 the use of copper alloy or stainless steel inserts molded in the fitting.

**1211.12 Polyvinyl Chloride (PVC) Pipe.** Joints between polyvinyl chloride pipe or 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 or 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 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 PVC components once the thread sealant has been applied. Female PVC threaded fittings shall be used with plastic male threads only.

**1211.13 Steel Pipe and Tubing.** Joints between steel pipe, tubing, or 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.

**1211.14 Joints Between Various Materials.** Joints between various materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 1211.14.1 and Section 1211.14.2.

**1211.14.1 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.

**1211.14.2 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.

**1212.0 Valves.**

**1212.1 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.
1212.2 Where Required. Valves shall be installed in hydronic piping systems in accordance with Section 1212.3 through Section 1212.11.

1212.3 Heat Exchanger. Isolation valves shall be installed on the supply and return side of the heat exchanger.

1212.4 Pressure Vessels. Isolation valves shall be installed on connections to pressure vessels.

1212.5 Pressure Reducing Valves. Isolation valves shall be installed on both sides of a pressure reducing valve.

1212.6 Equipment, Components, and Appliances. Serviceable equipment, components, and appliances within the system shall have isolation valves installed upstream and downstream of such devices.

1212.7 Expansion Tank. Isolation valves shall be installed at connections to non-diaphragm-type expansion tanks.

1212.8 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.

1212.9 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.

1212.10 Thermosiphoning. An approved type check valve shall be installed on liquid heat transfer piping to control thermosiphoning of heated liquids.

1212.11 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.

1213.0 System Controls.

1213.1 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.

1213.2 Operating Steam Controls. A steam heat source or system of commonly connected steam heat sources shall be protected by a pressure-actuated control to shut off the fuel supply where the system pressure reaches a pre-set operating pressure.

1213.2.1 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.

1213.3 Occupied Spaces. A temperature-sensing device shall be installed in the occupied space to regulate the operation of the hydronic system.

1213.4 Simultaneous Operation. Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling.

1213.5 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.

1214.0 Pressure and Flow Controls.

1214.1 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.

1214.2 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 1214.3. 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 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.

1214.3 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.

1214.4 Automatic Makeup Fluid. Where an automatic makeup fluid supply fill device is used to maintain the fluid content of the heat-source unit, or any closed loop in the system, the makeup supply shall be located at the expansion tank connection or other approved location.

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

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

A pressure-reducing valve shall be installed on a makeup water feed line. The pressure of the feed line shall be set in accordance with the design of the system, and connections to potable water shall be in accordance with Section 1202.0 to prevent contamination due to backflow.

1214.5 Differential Pressure Regulation. Provisions shall be made to control 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.

1214.5.1 Differential Pressure Bypass Valve. Where a differential pressure bypass valve is used for the purpose specified in Section 1214.5, it shall be installed and adjusted to provide bypass of the distribution system when most or all of the zones are closed.
1214.6 Air-Removal Device. Provision shall be made for the removal of air in the heat-distribution piping system 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.

1214.7 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 distribution hydronic system.

1214.8 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 an expansion tank in accordance with Section 1209.0, an air-removal device in accordance with Section 1214.6, and an air-separation device in accordance with Section 1214.7.

1215.0 Hydronic Space Heating.

1215.1 General. Based on the system design, the heat-distribution units shall be selected in accordance with the manufacturer’s specifications.

1215.2 Installation. Heat-distribution units shall be installed in accordance with the manufacturer’s installation instructions and this code.

1215.3 Freeze Protection. Hydronic systems and components shall be designed, installed, and protected from freezing.

1215.4 Balancing. System loops shall be installed so that the design flow rates are achieved within the system.

1215.5 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.

1216.0 Steam Systems.

1216.1 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.

1216.2 Sloping for Two-Pipe System. Two-pipe steam system piping and heat-distribution units shall be sloped down at not less than 1/8 inch per foot (10.4 mm/m) in the direction of the steam flow.

1216.3 Sloping for One-Pipe System. One-pipe steam system piping and heat-distribution units shall be sloped down at not less than 1/8 inch per foot (10.4 mm/m) towards the steam boiler, without trapping.

1216.4 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.

1216.5 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.

1216.6 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.

1217.0 Radiant Heating and Cooling.

1217.1 Installation. Radiant heating and cooling systems shall be installed in accordance with the system design.

1217.2 Radiant Under-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.

1217.3 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 not less than 3°F (2°C) above the anticipated space dewpoint temperature, or in accordance with the manufacturer’s recommendation. Chilled water piping, valves, and fittings shall be insulated and vapor sealed to prevent surface condensation.

1217.4 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, tube spacing and the individual loop lengths shall be installed with a variance of not more than ±10 percent from the design. 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 1217.4. Actual loop lengths shall be determined by spacing, flow rate, and pressure drop requirements as specified in the system design.
For the purpose of system balancing, each individual loop shall have a tag securely affixed to the manifold to indicate the length of the loop and the room(s) and area(s) served.

### TABLE 1217.4

<table>
<thead>
<tr>
<th>NOMINAL TUBE SIZE (inches)</th>
<th>MAXIMUM LOOP LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<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

#### 1217.5 Poured Floor Structural Concrete Slab Systems (Thermal Mass)

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.

**1217.5.1 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 sleeve 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.

**1217.5.2 Insulation.** Where a poured concrete radiant floor system is installed in contact with the soil, insulation approved 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.

**1217.5.3 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.

**1217.5.4 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).

**1217.5.31217.6 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.

**1217.6 Tubing Fasteners.** Tubing that is installed within joist spaces and subfloor panel systems shall be fastened according to manufacturer’s instructions. Unless prohibited by the manufacturer, tubing fasteners shall include the following:

1. Heat transfer panel systems made of wood, aluminum or other thermally conductive materials intended for this application and the specific type of tube.
2. Staples made of metal or plastic or combination thereof, without sharp edges that would harm tube, intended for this application and the specific type of tube fastened to subfloor.
3. Plastic rails with integrated tube holders intended for the specific type of tube.
4. Other fasteners recommended by the manufacturer.

**1217.5.41217.7 Wall and Ceiling Panels.** Where piping is installed in the stud wall cavity or the ceiling joist cavity, the cavity shall be insulated with not less than R-12 material. The insulation shall be installed in such a manner as to prevent heating or cooling loss from the space intended to be controlled.

An air space of not less than 1 inch (25.4 mm) and not more than 3 inches (76 mm) shall be maintained between the insulation and the interior surface of the panel unless a conductive plate is installed.

**1217.61217.8 Radiant Heating and Cooling Panels.** Radiant heating and cooling panels shall be installed in accor-
dance with the manufacturer’s installation instructions and shall be listed for the application.

Clearances for electric heating panels or between outlets, junction boxes, mounting luminaries, ventilating, or other openings shall comply with NFPA 70.

1217.6.21217.8.2 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 anchorage 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.

1218.0 Heat Exchangers.
1218.1 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 (3.048 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.

1219.0 Indirect-Fired Domestic Hot-Water Storage Tanks.
1219.1 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 as specified in Section 1207.3.1 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 potability of the water shall be maintained throughout the system.

1220.0 Auxiliary-Snow and Ice Melt Systems.
1220.1 Use of Chemical Additives and Corrosive Fluids. Where auxiliary systems contain chemical additives, corrosive fluids, or both not intended or designed for use in the primary system, a double wall heat exchanger shall be used in accordance with Section 1218.1. The chemical additives in the auxiliary systems shall be compatible with auxiliary system components and accepted for use by the heat exchanger manufacturer.

1220.2 Types of Tube Fasteners. Tubing that is embedded within concrete shall be fastened according to manufacturer’s instructions. Unless prohibited by the manufacturer, tube fasteners include the following:

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

1220.3 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).

1220.4 Snow and Ice Melt Controls. An automatic thermostatically operating control device that controls the supply hydronic solution 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.

1220.4.1 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.

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 1220.4.1. Actual loop lengths shall be determined by spacing, flow rate, and pressure drop in accordance with the system design.

### TABLE 1220.3.1220.4.1

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>1/4</td>
<td>115</td>
<td>140</td>
</tr>
<tr>
<td>3/8</td>
<td>225</td>
<td>250</td>
</tr>
<tr>
<td>1/2</td>
<td>300</td>
<td>325</td>
</tr>
<tr>
<td>1</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>Copper Tubing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/4</td>
<td>–</td>
<td>140</td>
</tr>
<tr>
<td>3/8</td>
<td>–</td>
<td>280</td>
</tr>
</tbody>
</table>

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 minimum Type L copper water tubing. In bituminous pavement use a Type K copper water tubing.

#### HYDRONICS

**4220.2.41220.4.2 Poured Structural Concrete Slab Systems (Thermal Mass).** 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 surface of the finished concrete slab.

**4220.2.41220.4.3 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 sleeve 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 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.

**4220.2.41220.4.4 Concrete Slab Preparation.** A solid foundation shall be prepared before the tubing is installed. Compaction shall be used for slabs, sidewalks, and driveways.

**4220.2.41220.4.5 Insulation.** Where a poured concrete snow melt system is installed in contact with the soil, insulation that has a recommended by the manufac-
turer for such application and with a minimum R-value of 5 shall be placed between the concrete and the compacted grade; and be extended as close as practical to the outside edges of the concrete and be placed on vertical slab edges that are in contact with plants or landscaping.

**4220.2.41220.4.6 Testing and Flushing.** Testing and flushing of snow and ice melt auxiliary systems shall be in accordance with Section 1205.01205.2 and flushing shall be in accordance with Section 1205.3.

**4220.31220.5 Hydronic Makeup Air Units.** Hydronic makeup air units that are affected by freezing shall be protected against freezing by a hydronic solution.

#### 1221.0 Piping Installation.

**1221.1 General.** Piping, fittings, and connections shall be installed in accordance with the conditions of their approval and manufacturer’s installation instructions.

**1221.2 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 100 psi at 180°F (689 kPa at 82°C). Joints of pipe or tubing that are embedded in a portion of the building, such as concrete or plastic shall be installed in accordance with the requirements of Section 1221.2.1 through Section 1221.2.3.

**1221.2.1 Steel Pipe.** Steel pipe shall be welded by electrical arc or oxygen/acetylene method.

**1221.2.2 Copper Tubing.** Copper tubing shall be joined by brazing with filler metals having a melting point not less than 1000°F (538°C).

**1221.2.3 Plastics.** Plastic pipe and tubing shall be installed in continuous lengths or shall be joined by heat fusion method.

**1221.3 Pressure Testing.** Piping to be embedded in concrete shall be pressure-tested in accordance with Section 1205.2 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.

**1221.4 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 1001.4. Embedded piping underground or under floors is not required to be designed for draining the system.

**1221.5 Condensate Drainage.** Condensate drains from dehumidifying coils shall be constructed and sloped for condensate removal. Such drains shall be installed in accordance with Section 310.0.

**1221.6 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 13
FUEL GAS PIPING

1301.0 Scope of Gas Piping.

1301.1 Applicability. The regulations of this chapter shall govern the installation of fuel gas piping in or in connection with a building, structure or within the property lines of premises up to 5 pounds-force per square inch (psi) (34 kPa) for natural gas and 10 psi (69 kPa) for undiluted propane, other than service pipe. Fuel oil piping systems shall be installed in accordance with NFPA 31.

1302.0 Coverage of Piping System.

1302.1 General. Coverage of piping systems shall extend from the point of delivery to the appliance connections. For other than undiluted liquefied petroleum gas (LP-Gas) systems, the point of delivery shall be the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where no meter is provided. For undiluted LP-Gas systems, the point of delivery shall be considered to be the outlet of the final pressure regulator, exclusive of line gas regulators where no meter is installed. Where a meter is installed, the point of delivery shall be the outlet of the meter. [NFPA 54:1.1.1.1(A)]

1302.2 Piping System Requirements. Requirements for piping systems shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation, and maintenance. [NFPA 54:1.1.1.1(C) 1.1.1.1(E)]

1302.3 Applications. This code shall not apply to the following items (reference standards for some of which appear in Chapter 17):

(1) Portable LP-Gas appliances and equipment of all types that are not connected to a fixed fuel piping system.
(2) Installation of appliances such as brooders, dehydrators, dryers, and irrigation equipment used for agricultural purposes.
(3) Raw material (feedstock) applications except for piping to special atmosphere generators.
(4) Oxygen-fuel gas cutting and welding systems.
(5) Industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen, and nitrogen.
(6) Petroleum refineries, pipeline compressor or pumping stations, loading terminals, compounding plants, refinery tank farms, and natural gas processing plants.
(7) Large integrated chemical plants or portions of such plants where flammable or combustible liquids or gases are produced by chemical reactions or used in chemical reactions.
(8) LP-Gas installations at utility gas plants.
(9) Liquefied natural gas (LNG) installations.
(10) Fuel gas piping in electric utility power plants.
(11) Proprietary items of equipment, apparatus, or instruments such as gas-generating sets, compressors, and calorimeters.

(12) LP-Gas equipment for vaporization, gas mixing, and gas manufacturing.
(13) LP-Gas piping for buildings under construction or renovations that is not to become part of the permanent building piping system—that is, temporary fixed piping for building heat.
(14) Installation of LP-Gas systems for railroad switch heating.
(15) Installation of LP-Gas and compressed natural gas (CNG) systems on vehicles.
(16) Gas piping, meters, gas-pressure regulators, and other appurtenances used by the serving gas supplier in distribution of gas, other than undiluted LP-Gas.
(17) Building design and construction, except as specified herein.
(18) Fuel gas systems on recreational vehicles manufactured in accordance with NFPA 1192.
(19) Fuel gas systems using hydrogen as a fuel.
(20) Construction of appliances. [NFPA 54:1.1.1.2]

1303.0 Inspection.

1303.1 Inspection Notification. Upon completion of the installation, alteration, or repair of gas piping, and prior to the use thereof, the Authority Having Jurisdiction shall be notified that such gas piping is ready for inspection.

1303.2 Excavation. Excavations required for the installation of underground piping shall be kept open until such time as the piping has been inspected and approved. Where such piping is covered or concealed before such approval, it shall be exposed upon the direction of the Authority Having Jurisdiction.

1303.3 Type of Inspections. The Authority Having Jurisdiction shall make the following inspections and either shall approve that portion of the work as completed or shall notify the permit holder wherein the same fails to be in accordance with this code.

1303.3.1 Rough Piping Inspection. This inspection shall be made after gas piping authorized by the permit has been installed before such piping has been covered or concealed, or before fixture or appliance has been attached thereto. This inspection shall include a determination that the gas piping size, material, and installation meet the requirements of this code.

1303.3.2 Final Piping Inspection. This inspection shall be made after piping authorized by the permit has been installed and after portions thereof that are to be covered or concealed are so concealed and before fixture, appliance, or shutoff valve has been attached thereto. This inspection shall comply with Section...
1303.1 Test Gauges. Tests required by this code, which are performed utilizing dial gauges, shall be limited to gauges having the following pressure graduations or increments.

1303.3.1 Pressure Tests (10 psi or less). Required pressure tests of 10 psi (69 kPa) or less shall be performed with gauges of 0.10 psi (0.69 kPa) increments or less.

1303.3.2 Pressure Tests (greater than 10 psi to 100 psi). Required pressure tests exceeding 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall be performed with gauges of 1 psi (7 kPa) increments or less.

1303.3.3 Pressure Tests (exceeding 100 psi). Required pressure tests exceeding 100 psi (689 kPa) shall be performed with gauges of 2 percent increments or less of the required test pressure.

1303.3.4 Pressure Range. Test gauges shall have a pressure range not exceeding twice the test pressure applied.

1303.4 Inspection Waived. In cases where the work authorized by the permit consists of a minor installation of additional piping to piping already connected to a gas meter, the foregoing inspections shall be permitted to be waived at the discretion of the Authority Having Jurisdiction. In this event, the Authority Having Jurisdiction shall 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.

1304.0 Certificate of Inspection.

1304.1 Issuance. Whereupon final piping inspection, the installation is found to be in accordance with the provisions of this code, a certificate of inspection shall be permitted to be issued by the Authority Having Jurisdiction.

1304.2 Gas Supplier. A copy of the certificate of such final piping inspection shall be issued to the serving gas supplier supplying gas to the premises.

1304.3 Unlawful. It shall be unlawful for a serving gas supplier or person furnishing gas, to turn on or cause to be turned on, fuel gas or a gas meter or meters until such certificate of final inspection, as herein provided, has been issued.

1305.0 Authority to Render Gas Service.

1305.1 Authorized Personnel. It shall be unlawful for a person, firm, or corporation, excepting an authorized agent or employee of a person, firm, or corporation engaged in the business of furnishing or supplying gas and whose service pipes supply or connect with the particular premises, to turn on or reconnect gas service in or on a premises where gas service is, at the time, not being rendered.

1305.2 Outlets. It shall be unlawful to turn on or connect gas in or on the premises unless outlets are securely connected to gas appliances or capped or plugged with screw joint fittings.

1306.0 Authority to Disconnect.

1306.1 Disconnection. The Authority Having Jurisdiction or the serving gas supplier is hereby authorized to disconnect gas piping or appliance or both that shall be found not to be in accordance with the requirements of this code or that are found defective and in such condition as to endanger life or property.

1306.2 Notice. Where such disconnection has been made, a notice shall be attached to such gas piping or appliance or both that shall state the same has been disconnected, together with the reasons thereof.

1306.3 Capped Outlets. It shall be unlawful to remove or disconnect gas piping or gas appliance without capping or plugging with a screw joint fitting, the outlet from which said pipe or appliance was removed. Outlets to which gas appliances are not connected shall be left capped and gastight on a piping system that has been installed, altered, or repaired.

Exception: Where an approved listed quick-disconnect device is used.

1307.0 Temporary Use of Gas.

1307.1 General. Where temporary use of gas is desired, and the Authority Having Jurisdiction deems the use necessary, a permit shall be permitted to be issued for such use for a period of time not to exceed that designated by the Authority Having Jurisdiction, provided that such gas piping system otherwise is in accordance with to the requirements of this code regarding material, sizing, and safety.

1308.0 Gas Piping System Design, Materials, and Components.

1308.1 Installation of Piping System. Where required by the Authority Having Jurisdiction, a piping sketch or plan shall be prepared before proceeding with the installation. The plan shall show the proposed location of piping, the size of different branches, the various load demands, and the location of the point of delivery. [NFPA 54:5.1.1]

1308.1.1 Addition to Existing System. When additional appliances are being connected to a gas piping system, the existing piping shall be checked to determine whether it has adequate capacity. If the capacity of the system is determined to be inadequate for the additional appliances, the existing system shall be enlarged as required, or separate gas piping of adequate capacity shall be provided. [NFPA 54:5.1.2—5.1.2.2]

1308.2 Provision for Location of Point of Delivery. The location of the point of delivery shall be acceptable to the serving gas supplier. [NFPA 54:5.2]

1308.3 Interconnections Between Gas Piping Systems. Where two or more meters, or two or more service regulators where meters are not provided, are located on the same premises and supply separate users, the gas piping systems shall not be interconnected on the outlet side of the meters or service regulators. [NFPA 54:5.3.1]

1308.3.1 Interconnections for Standby Fuels. Where a supplementary gas for standby use is connected downstream from a meter or a service regulator where a
meter is not provided, equipment to prevent backflow shall be installed. A three-way valve installed to admit the standby supply and at the same time shut off the regular supply shall be permitted to be used for this purpose. [NFPA 54:5.3.2 – 5.3.2.2]

1308.4 Sizing of Gas Piping Systems. Gas piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand and supply gas to each appliance inlet at not less than the minimum supply pressure required by the appliance. [NFPA 54:5.4.1]

1308.4.1 Maximum Gas Demand. The volumetric flow rate of gas to be provided shall be the sum of the maximum inputs of the appliances served. The volumetric flow rate of gas to be provided shall be adjusted for altitude where the installation is above 2 000 feet (610 m). [NFPA 54:5.4.2.1 – 5.4.2.2] Where the input rating is not indicated, the gas supplier, appliance manufacturer, or a qualified agency shall be contacted or the rating from Table 1308.4.1 shall be used for estimating the volumetric flow rate of gas to be supplied.

The total connected hourly load shall be used as the basis for pipe sizing, assuming all appliances are operating at full capacity simultaneously.

Exception: Sizing shall be permitted to be based upon established load diversity factors. [NFPA 54:5.4.2.1 – 5.4.2.3]

1308.4.2 Sizing Methods. Gas piping shall be sized in accordance with one of the following:

(1) Pipe sizing tables or sizing equations in this chapter.

(2) Other approved engineering methods acceptable to the Authority Having Jurisdiction.

(3) Sizing tables included in a listed piping system manufacturer's installation instructions. [NFPA 54:5.4.3]

1308.4.3 Allowable Pressure Drop. The design pressure loss in any piping system under maximum probable flow conditions, from the point of delivery to the inlet connection of the appliance, shall be such that the supply pressure at the appliance is greater than or equal to the minimum pressure required by the appliance. [NFPA 54:5.4.4]

1308.5 Acceptable Piping Materials and Joining Methods. Materials used for piping systems shall either comply with the requirements of this chapter or be acceptable to the Authority Having Jurisdiction. [NFPA 54:5.6.1.1]

1308.5.1 Used Materials. Pipe, fittings, valves, or other materials shall not be used again unless they are free of foreign materials and have been ascertained to be adequate for the service intended. [NFPA 54:5.6.1.2]

1308.5.1.1 Other Materials. Material not covered by the standards specifications listed herein shall meet the following criteria:

(1) Be investigated and tested to determine that it is safe and suitable for the proposed service.

(2) Be recommended for that service by the manufacturer.

(3) Be acceptable to the Authority Having Jurisdiction. [NFPA 54:5.6.1.3]

1308.5.2 Metallic Pipe. Cast-iron pipe shall not be used. [NFPA 54:5.6.2.1]

1308.5.2.1 Steel, Stainless Steel, and Wrought-Iron. Steel, stainless steel, and wrought-iron pipe shall be at least not less than standard weight (Schedule 40) and shall comply with the dimensional standards of ASME B36.10M and one of the following standards:

(1) ASME B36.10ASTM A312

(2) ASTM A53

(3) ASTM A106 [NFPA 54:5.6.2.2]

1308.5.2.2 Copper and Copper Alloy Pipe. Copper and copper alloy pipe shall not be used where the gas contains more than an average of 0.3

<table>
<thead>
<tr>
<th>TABLE 1308.4.1</th>
<th>APPROXIMATE GAS INPUT FOR TYPICAL APPLIANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLIANCE</td>
<td>INPUT (Btu/h approx.)</td>
</tr>
<tr>
<td>Space Heating Units</td>
<td></td>
</tr>
<tr>
<td>Warm air furnace</td>
<td>100 000</td>
</tr>
<tr>
<td>Single family</td>
<td>60 000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60 000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60 000</td>
</tr>
<tr>
<td>Hydronic boiler</td>
<td>100 000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60 000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60 000</td>
</tr>
<tr>
<td>Space and Water Heating Units</td>
<td></td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>120 000</td>
</tr>
<tr>
<td>Hydronic boiler</td>
<td>75 000</td>
</tr>
<tr>
<td>Water Heating Appliances</td>
<td></td>
</tr>
<tr>
<td>Water heater, automatic storage</td>
<td>35 000</td>
</tr>
<tr>
<td>30 to 40 gallon tank</td>
<td></td>
</tr>
<tr>
<td>Water heater, automatic storage</td>
<td>50 000</td>
</tr>
<tr>
<td>50 gallon tank</td>
<td></td>
</tr>
<tr>
<td>Water heater, automatic instantaneous</td>
<td>142 800</td>
</tr>
<tr>
<td>Capacity at 2 gallons per minute</td>
<td></td>
</tr>
<tr>
<td>Water heater, automatic instantaneous</td>
<td>285 000</td>
</tr>
<tr>
<td>Capacity at 4 gallons per minute</td>
<td></td>
</tr>
<tr>
<td>Water heater, domestic, circulating or side-arm</td>
<td>428 400</td>
</tr>
<tr>
<td>Capacity at 6 gallons per minute</td>
<td></td>
</tr>
<tr>
<td>Water heater, domestic, circulating or side-arm</td>
<td>35 000</td>
</tr>
<tr>
<td>Cooking Appliances</td>
<td></td>
</tr>
<tr>
<td>Range, freestanding, domestic</td>
<td>65 000</td>
</tr>
<tr>
<td>Built-in oven or broiler unit, domestic</td>
<td>25 000</td>
</tr>
<tr>
<td>Built-in top unit, domestic</td>
<td>40 000</td>
</tr>
<tr>
<td>Other Appliances</td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>3000</td>
</tr>
<tr>
<td>Clothes dryer, Type 1 (domestic)</td>
<td>35 000</td>
</tr>
<tr>
<td>Gas fireplace direct vent</td>
<td>40 000</td>
</tr>
<tr>
<td>Gas log</td>
<td>80 000</td>
</tr>
<tr>
<td>Barbecue</td>
<td>40 000</td>
</tr>
<tr>
<td>Gaslight</td>
<td>2500</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW
grains of hydrogen sulfide per 100 standard cubic feet (scf) of gas (0.7 mg/100 L).

Threaded copper, copper alloy, or aluminum alloy pipe shall not be used with gases corrosive to such material.

1308.5.2.3 Aluminum Alloy. Aluminum alloy pipe shall comply with ASTM B241 (except that the use of alloy 5456 is prohibited), and shall be marked at each end of each length indicating compliance. Aluminum alloy pipe shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation or is subject to repeated wettings by such liquids as water, detergents, or sewage. [NFPA 54:5.6.2.5]

Aluminum alloy pipe shall not be used in exterior locations or underground. [NFPA 54:5.6.2.6]

1308.5.3 Metallic Tubing. Seamless copper, aluminum alloy, or steel tubing shall not be used with gases corrosive to the tubing material. [NFPA 54:5.6.3.1]

1308.5.3.1 Stainless Steel. Stainless steel tubing shall comply with one of the following:

(1) ASTM A268
(2) ASTM A269 [NFPA 54:5.6.3.3]

1308.5.3.2 Steel. Steel tubing shall comply with ASTM A254. [NFPA 54:5.6.3.1]

1308.5.3.3 Copper and Copper Alloy Tubing. Copper and copper alloy tubing shall not be used where the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 scf of gas (0.7 mg/100 L). Copper tubing shall comply with standard Type K or L of ASTM B88 or ASTM B280.

1308.5.3.4 Aluminum Alloy Tubing. Aluminum alloy tubing shall comply with ASTM B210 or ASTM B241. Aluminum alloy tubing shall be coated to protect against external corrosion where it is in contact with masonry, plaster, insulation, or is subject to repeated wettings by such liquids as water, detergent, or sewage. Aluminum alloy tubing shall not be used in exterior locations or underground. [NFPA 54:5.6.3.5]

1308.5.3.5 Corrugated Stainless Steel Tubing. Corrugated stainless steel tubing shall be listed in accordance with CSA LC-1. [NFPA 54:5.6.3.4]

1308.5.4 Plastic Pipe, Tubing, and Fittings. Polyethylene plastic pipe, tubing, and fittings used to supply fuel gas shall conform to ASTM D2513. Pipe to be used shall be marked “gas” and “ASTM D2513.” [NFPA 54:5.6.4.1.1] Polyamide pipe, tubing, and fittings shall be identified in and conform to ASTM F2945. Pipe to be used shall be marked “gas” and “ASTM F2945.” [NFPA 54:5.6.4.1.2] Polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) plastic pipe, tubing, and fittings shall not be used to supply fuel gas. [NFPA 54:5.6.4.1.3]

1308.5.4.1 Regulator Vent Piping. Plastic pipe and fittings used to connect regulator vents to remote vent terminations shall be PVC in accordance with UL 651. PVC vent piping shall not be installed indoors. [NFPA 54:5.6.4.2]

1308.5.4.2 Anodeless Risers. Anodeless risers shall comply with Section 1308.5.4.2.1 through Section 1308.5.4.2.3. [NFPA 54:5.6.4.3]

1308.5.4.2.1 Factory-Assembled Anodeless Risers. Factory-assembled anodeless risers shall be recommended by the manufacturer for the gas used and shall be leak-tested by the manufacturer in accordance with written procedures. [NFPA 54:5.6.4.3(1)]

1308.5.4.2.2 Service Head Adapters and Field-Assembled Anodeless Risers. Service head adapters and field assembled anodeless risers incorporating service head adapters shall be recommended by the manufacturer for the gas used and shall be design-certified to be in accordance with the requirements of Category I of ASTM D2513. The manufacturer shall provide the user qualified installation instructions. [NFPA 54:5.6.4.3(2)]

1308.5.4.2.3 Undiluted Liquefied Petroleum Gas Piping. The use of plastic pipe, tubing, and fittings in undiluted LP-Gas piping systems shall be in accordance with NFPA 58. [NFPA 54:5.6.4.3(3)]

1308.5.5 Workmanship and Defects. Gas pipe, tubing, and fittings shall be clear and free from cutting burrs and defects in structure or threading, and shall be thoroughly brushed and chip and scale blown. Defects in pipe, tubing, and fittings shall not be repaired. Defective pipe, tubing, and fittings shall be replaced. [NFPA 54:5.6.5]

1308.5.6 Protective Coating. Where in contact with material or atmosphere exerting a corrosive action, metallic piping and fittings coated with a corrosion-resistant material shall be used. External or internal coatings or linings used on piping or components shall not be considered as adding strength. [NFPA 54:5.6.6]

1308.5.7.1308.5.6 Metallic Pipe Threads. Metallic pipe and fitting threads shall be taper pipe threads and shall comply with ASME B1.20.1. [NFPA 54:5.6.7.1]

1308.5.7.2 Damaged Threads. Pipe with threads that are stripped, chipped, corroded, or otherwise damaged shall not be used. Where a weld opens during the operation of cutting or threading, that portion of the pipe shall not be used. [NFPA 54:5.6.7.2]

1308.5.7.2 Number of Threads. Field threading of metallic pipe shall be in accordance with Table 1308.5.7.2. [NFPA 54:5.6.7.3]
### Table 1308.5.7.2 Specifications for Threading Metallic Pipe

**[NFPA 54: Table 5.6.7.3]**

<table>
<thead>
<tr>
<th>Iron Pipe Size (Inches)</th>
<th>Approximate Length of Threaded Portion (Inches)</th>
<th>Approximate Number of Threads to Be Cut</th>
</tr>
</thead>
<tbody>
<tr>
<td>½</td>
<td>¾</td>
<td>10</td>
</tr>
<tr>
<td>¾</td>
<td>¾</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>¾</td>
<td>10</td>
</tr>
<tr>
<td>1½</td>
<td>¾</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>2½</td>
<td>1½</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>1½</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>1½</td>
<td>13</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

#### 1308.5.7.3 Thread Joint Compounds
Thread joint compounds shall be resistant to the action of LP-Gas or to any other chemical constituents of the gases to be conducted through the piping. [NFPA 54:5.6.7.4]

#### 1308.5.8 Metallic Piping Joints and Fittings
The type of piping joint used shall be suitable for the pressure and temperature conditions and shall be selected giving consideration to joint tightness and mechanical strength under the service conditions. The joint shall be able to sustain the maximum end force due to the internal pressure and any additional forces due to temperature expansion or contraction, vibration, fatigue, or the weight of the pipe and its contents. [NFPA 54:5.6.8]

**1308.5.8.1 Pipe Joints**
Pipe joints shall be threaded, flanged, brazed, welded, or press connect fittings made in accordance with CSA LC-4. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus.

**1308.5.8.2 Tubing Pipe Joints**
Schedule 40 and heavier pipe joints shall either be made threaded, flanged, brazed, welded, or assembled with approved gas tubing press-connect fittings, listed to CSA LC 4, be brazed with a material having:

1. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1000°F (538°C), or made by press-connect fittings in accordance with CSA LC 4.
   
2. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.8.2]

**1308.5.7.2 Copper Tubing Joints**
Copper tubing joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1000°F (538°C), or shall be assembled with press-connect fittings listed to CSA LC 4, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.7.2]

**1308.5.7.3 Stainless Steel Tubing Joints**
Stainless steel joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1000°F (538°C), or assembled with press-connect fittings listed to CSA LC 4, Press-Connect Metallic Fittings for Use in Fuel Gas Distribution Systems. Brazing alloys and fluxes shall be recommended by the manufacturer for use on stainless steel alloys. [NFPA 54:5.6.7.3]

**1308.5.8.3 Flared Joints**
Flared joints shall be used in systems constructed from nonferrous pipe and tubing where experience or tests have demonstrated that the joint is approved suitable for the conditions and where provisions are made in the design to prevent separation of the joints. [NFPA 54:5.6.8.3]

**1308.5.8.4 Metallic Pipe Fittings (Including Valves, Strainers, Filters)**
Metallic pipe fittings shall comply with the following:

1. Threaded fittings in sizes exceeding 4 inches (100 mm) shall not be used unless acceptable to the Authority Having Jurisdiction.
2. Fittings used with steel, stainless steel, or wrought-iron pipe shall be steel, stainless steel, copper alloy, bronze, malleable iron, or cast-iron.
3. Fittings used with copper or copper alloy pipe shall be copper or copper alloy.
4. Fittings used with aluminum alloy pipe shall be of aluminum alloy.
5. Cast-iron fittings shall comply with the following:
   a. Flanges shall be permitted.
   b. Bushings shall not be used.
   c. Fittings shall not be used in systems containing flammable gas-air mixtures.
   d. Fittings in sizes 4 inches (100 mm) and larger shall not be used indoors unless approved by the Authority Having Jurisdiction.
   e. Fittings in sizes 6 inches (150 mm) and larger shall not be used unless approved by the Authority Having Jurisdiction.
6. Aluminum alloy fitting threads shall not form the joint seal.
7. Zinc-aluminum alloy fittings shall not be used in systems containing flammable gas-air mixtures.
(8) Special fittings such as couplings; proprietary-type joints; saddle tees; gland-type compression fittings; and flared, flareless, or compression-type tubing fittings shall be as follows:
   (a) Used within the fitting manufacturer’s pressure-temperature recommendations.
   (b) Used within the service conditions anticipated with respect to vibration, fatigue, thermal expansion, or contraction.
   (c) installed or braced to prevent separation of the joint by gas pressure or external physical damage.
   (d) Acceptable to the Authority Having Jurisdiction.

1308.5.9.1 1308.5.8 Plastic Piping, Joints, and Fittings. Plastic pipe, tubing, and fittings shall be installed in accordance with the manufacturer’s installation instructions. Section 1308.5.9.1 through Section 1308.5.9.4 1308.5.8.4 shall be observed where making such joints. [NFPA 54:5.6.9(1) 5.6.8]

1308.5.9.1.1 1308.5.8.1 Joint Design. The joint shall be designed and installed so that the longitudinal pullout resistance of the joint will be at least equal to the tensile strength of the plastic piping material. [NFPA 54:5.6.9(1) 5.6.8(1)]

1308.5.9.2 1308.5.8.2 Heat-Fusion Joint. Heat-fusion joints shall be made in accordance with qualified procedures that have been established and proven by test to produce gastight joints as strong as the pipe or tubing being joined. Joints shall be made with the joining method recommended by the pipe manufacturer. Heat-fusion fittings shall be marked “ASTM D2513.” [NFPA 54:5.6.9(2) 5.6.8(2)]

1308.5.9.3 1308.5.8.3 Compression-Type Mechanical Joints. Where compression-type mechanical joints are used, the gasket material in the fitting shall be compatible with the plastic piping and with the gas distributed by the system. An internal tubular rigid stiffener shall be used in conjunction with the fitting. The stiffener shall be flush with the end of the pipe or tubing and shall extend not less than the outside end of the compression fitting where installed. The stiffener shall be free of rough or sharp edges and shall not be a forced fit in the plastic. Split tubular stiffeners shall not be used. [NFPA 54:5.6.9(3) 5.6.8(3)]

1308.5.9.4 1308.5.8.4 Liquefied Petroleum Gas Piping Systems. Plastic piping joints and fittings for use in LP-Gas piping systems shall be in accordance with NFPA 58. [NFPA 54:5.6.9(4) 5.6.8(4)]

1308.5.10 1308.5.9 Flange Specification. Cast iron flanges shall be in accordance with ASME B16.1. [NFPA 54:5.6.10.1.1 5.6.9.1.1]

1308.5.10.4 1308.5.9.1 Steel Flanges. Steel flanges shall be in accordance with the following:
   (1) ASME B16.5 or
   (2) ASME B16.47. [NFPA 54:5.6.10.1.2]

1308.5.10.21 1308.5.9.2 Non-Ferrous Flanges. Non-ferrous flanges shall be in accordance with ASME B16.24. [NFPA 54:5.6.10.1.3 5.6.9.1.3]

1308.5.10.31 1308.5.9.3 Ductile Iron Flanges. Ductile iron flanges shall be in accordance with ASME B16.42. [NFPA 54:5.6.10.1.4 5.6.9.1.4]

1308.5.10.41 1308.5.9.4 Dissimilar Flange Connections. Dissimilar flange connections shall be made in accordance with ASME B16.50, unless the manufacturer’s installation instructions for use in cast-iron and ductile iron flange joints shall be in accordance with ASME B16.42. [NFPA 54:5.6.10.2 5.6.9.2]

1308.5.10.51 1308.5.9.5 Flange Facings. Standard flange facings shall be permitted for use under this code. Where 150 psi (1034 kPa) steel flanges are bolted to Class 125 cast-iron flanges, the raised face on the steel flange shall be removed. [NFPA 54:5.6.10.3 5.6.9.3]

1308.5.10.61 1308.5.9.6 Lapped Flanges. Lapped flanges shall be used only aboveground or in exposed locations accessible for inspection. [NFPA 54:5.6.10.4 5.6.9.4]

1308.5.11 1308.5.10 Flange Gaskets. The material for gaskets shall be capable of withstanding the design temperature and pressure of the piping system and the chemical constituents of the gas being conducted without change to its chemical and physical properties. The effects of fire exposure to the joint shall be considered in choosing the material. [NFPA 54:5.6.11.1 5.6.10.1]

1308.5.11.1 1308.5.10.1 Flange Gasket Materials. Acceptable materials shall include the following:
   (a) Metal (plain or corrugated)
   (b) Composition
   (c) Aluminum “O” rings
   (d) Spiral-wound metal gaskets
   (e) Rubber-faced phenolic
   (f) Elastomeric [NFPA 54:5.6.11.1 5.6.10.1]

1308.5.11.2 1308.5.10.2 Metallic Flange Gaskets. Metallic flange gaskets shall be in accordance with ASME B16.20. [NFPA 54:5.6.11.2 5.6.10.2.1]

1308.5.11.3 1308.5.10.3 Non-Metallic Flange Gaskets. Non-metallic flange gaskets shall be in accordance with ASME B16.21. [NFPA 54:5.6.11.3 5.6.10.2.2]

1308.5.11.4 1308.5.10.4 Full-Face Flange Gasket. Full-face flange gaskets shall be used with all non-steel flanges. [NFPA 54:5.6.11.4 5.6.10.3]

1308.5.11.5 1308.5.10.5 Separated Flanges. When a flange joint is separated, the gasket shall be replaced. [NFPA 54:5.6.11.5 5.6.10.4]

1308.6 Gas Meters. Gas meters shall be selected for the maximum expected pressure and permissible pressure drop. [NFPA 54:5.7.1.1]

1308.6.1 Location. Gas meters shall be located in ventilated spaces readily accessible for examination, reading, replacement, or necessary maintenance. [NFPA 54:5.7.2.1]
1308.6.1.1 Subject to Damage. Gas meters shall not be placed where they will be subjected to damage, such as adjacent to a driveway, under a fire escape, in public passages, halls, or where they will be subject to excessive corrosion or vibration. [NFPA 54:5.7.2.2]

1308.6.1.2 Extreme Temperatures. Gas meters shall not be located where they will be subjected to extreme temperatures or sudden extreme changes in temperature or in areas where they are subjected to temperatures beyond those recommended by the manufacturer. [NFPA 54:5.7.2.3]

1308.6.2 Supports. Gas meters shall be supported or connected to rigid piping so as not to exert a strain on the meters. Where flexible connectors are used to connect a gas meter to downstream piping at mobile homes in mobile home parks, the meter shall be supported by a post or bracket placed in a firm footing or by other means providing equivalent support. [NFPA 54:5.7.3]

1308.6.3 Meter Protection. Meters shall be protected against overpressure, backpressure, and vacuum. [NFPA 54:5.7.4]

1308.6.4 Identification. Gas piping at multiple meter installations shall be marked by a metal tag or other permanent means designating the building or the part of the building being supplied and attached by the installing agency. [NFPA 54:5.7.5]

1308.7 Gas Pressure Regulators. A line pressure regulator or gas appliance pressure regulator, as applicable, shall be installed where the gas supply pressure is higher than that at which the branch supply line or appliances are designed to operate or vary beyond design pressure limits, exceeds the maximum allowable inlet pressure of the appliance served. [NFPA 54:5.8.1]

1308.7.1 Listing. Line pressure regulators shall be listed in accordance with CSA Z21.80 where the outlet pressure is set to 2 psi (14 kPa) or less. [NFPA 54:5.8.2]

1308.7.2 Location. The gas pressure regulator shall be accessible for servicing. [NFPA 54:5.8.3]

1308.7.3 Regulator Protection. Pressure regulators shall be protected against physical damage. [NFPA 54:5.8.4]

1308.7.4 Venting of Line Pressure Regulators. Line pressure regulators shall comply with all of the following:

1. An independent vent to the exterior of the building, sized in accordance with the regulator manufacturer’s instructions, shall be provided where the location of a regulator is such that a ruptured diaphragm will cause a hazard. Where more than one regulator is at a location, each regulator shall have a separate vent to the outdoors or, if approved by the Authority Having Jurisdiction, the vent lines shall be permitted to be manifolded in accordance with accepted engineering practices to minimize backpressure in the event of diaphragm failure. Materials for vent piping shall be in accordance with Section 1308.5 through Section 1308.5.14 through 1308.5.10.5.

Exception: A regulator and vent limiting means combination listed as complying with CSA Z21.80 shall be permitted to be used without a vent to the outdoors.

2. The vent shall be designed to prevent the entry of water, insects, or other foreign materials that could cause blockage.

3. The regulator vent shall terminate at least 3 feet (914 mm) from a source of ignition.

4. At locations where regulators might be submerged during floods, a special antiflood-type breather vent fitting shall be installed, or the vent line shall be extended above the height of the expected flood waters.

5. A regulator shall not be vented to the appliance flue or exhaust system. [NFPA 54:5.8.5.1]

1308.7.5 Venting of Gas Appliance Pressure Regulators. For venting of gas appliance pressure regulators, see Section 902.15. [NFPA 54:5.8.5.2]

1308.7.6 Bypass Piping. Valved and regulated bypasses shall be permitted to be placed around gas line pressure regulators where continuity of service is imperative. [NFPA 54:5.8.6]

1308.7.7 Identification. Line pressure regulators at multiple regulator installations shall be marked by a metal tag or other permanent means designating the building or the part of the building being supplied. [NFPA 54:5.8.7]

1308.8 Overpressure Protection. Where the serving gas supplier delivers gas at a pressure greater than 2 psi for piping systems serving appliances designed to operate at a gas pressure of 14 inches water column or less, overpressure protection devices shall be installed. Piping systems serving equipment designed to operate at inlet pressures greater than 14 inches water column (3.5 kPa) shall be equipped with overpressure protection devices as required by the appliance manufacturer’s installation instructions. [NFPA 54:5.9.1]

1308.9 Pressure Limitation Requirements. Where piping systems serving appliances designed to operate with a gas supply pressure of 14 inches water column or less are required to be equipped with overpressure protection by Section 1308.8, each overpressure protection device shall be adjusted to limit the gas pressure to each connected appliance to 2 psi or less upon a failure of the line pressure regulator. [NFPA 54:5.9.2.1]

1308.9.1 Overpressure Protection Required. Where piping systems serving appliances designed to operate with a gas supply pressure greater than 14 inches water column are required to be equipped with overpressure protection by Section 1308.8, each overpressure protection device shall be adjusted to limit the gas pressure to each connected appliance as required by the appliance manufacturer’s installation instructions. [NFPA 54:5.9.2.2]

1308.9.2 Overpressure Protection Devices. Each overpressure protection device installed to meet the requirements of this section shall be capable of limiting
the pressure to its connected appliance(s) as required by this section independently of any other pressure control equipment in the piping system. [NFPA 54:5.9.2.3]

1308.9.3 Detection of Failure. Each gas piping system for which an overpressure protection device is required by this section shall be designed and installed so that a failure of the primary pressure control device(s) is detectable. [NFPA 54:5.9.2.4]

1308.9.4 Flow Capacity. If a pressure relief valve is used to meet the requirements of this section, it shall have a flow capacity such that the pressure in the protected system is maintained at or below the limits specified in Section 1308.9 under the following conditions:

1. The line pressure regulator for which the relief valve is providing overpressure protection has failed wide open.
2. The gas pressure at the inlet of the line pressure regulator for which the relief valve is providing overpressure protection is not less than the regulator’s normal operating inlet pressure. [NFPA 54:5.9.2.5]

1308.10 Overpressure Protection Devices. Overpressure protection devices shall be one of the following:

1. Pressure relief valve.
3. Series regulator installed upstream from the line regulator and set to continuously limit the pressure on the inlet of the line regulator to the maximum values specified by Section 1308.9 or less.
4. Automatic shutoff device installed in series with the line pressure regulator and set to shut off when the pressure on the downstream piping system reaches the maximum values specified by Section 1308.9 or less. This device shall be designed so that it will remain closed until manually reset. [NFPA 54:5.9.3.1]

1308.10.1 Separate Devices. The devices in Section 1308.10 shall be installed either as an integral part of the service or line pressure regulator or as separate units. Where separate overpressure protection devices are installed, they shall comply with Section 1308.10.2 through Section 1308.10.7. [NFPA 54:5.9.3.2]

1308.10.2 Construction and Installation. All overpressure protection devices shall meet the following requirements:

1. Be constructed of materials so that the operation of the device is not impaired by corrosion of external parts by the atmosphere or of internal parts by the gas.
2. Be designed and installed so they can be operated to determine whether the valve is free. The devices shall also be designed and installed so they can be tested to determine the pressure at which they operate and be examined for leakage when in the closed position. [NFPA 54:5.9.4]

1308.10.3 External Control Piping. External control piping shall be designed and installed so that damage to the control piping of one device does not render both the regulator and the overpressure protective device inoperative. [NFPA 54:5.9.5]

1308.10.4 Setting. Each pressure limiting or pressure relieving device shall be set so that the gas pressure supplied to the connected appliance(s) does not exceed the limits specified in Section 1308.9 and Section 1308.9.1. [NFPA 54:5.9.6]

1308.10.5 Unauthorized Operation. Where unauthorized operation of any shutoff valve could render a pressure relieving valve or pressure limiting device inoperative, one of the following shall be accomplished:

1. The valve shall be locked in the open position. Instruct authorized personnel in the importance of leaving the shutoff valve open and of being present while the shutoff valve is closed so that it can be locked in the open position before leaving the premises.
2. Duplicate relief valves shall be installed, each having adequate capacity to protect the system, and arrange the isolating valves or three-way valve so that only one relief valve can be rendered inoperative at a time. [NFPA 54:5.9.7]

1308.11.10.6 Discharge of Vents. The discharge of vents shall be in accordance with the following:

1. The discharge stacks, vents, or outlet parts of all pressure-relieving and pressure-limiting devices shall be located so that gas is safely discharged to the outdoors.
2. Discharge stacks or vents shall be designed to prevent the entry of water, insects, or other foreign material that could cause blockage. The discharge stack or vent line shall be at least the same size as the outlet of the pressure-relieving device. [NFPA 54:5.9.8.1, 5.9.8.2]

1308.10.7 Size of Fittings, Pipe, and Openings. The fittings, pipe, and openings located between the system to be protected and the pressure relieving device shall be sized to prevent hammering of the valve and to prevent impairment of relief capacity. [NFPA 54:5.9.9]

1308.10.11 Backpressure Protection. Protective devices shall be installed as close to the equipment as practical where the design of the equipment connected is such that air, oxygen, or standby gases are capable of being forced into the gas supply system. Gas and air combustion mixers incorporating double diaphragm “zero” or “atmosphere” governors or regulators shall require no further protection unless connected directly to compressed air or oxygen at pressures of 5 psi (34 kPa) or more. [NFPA 54:5.10.1.1, 5.10.1.2]

1308.11.11.1 Protective Devices. Protective devices shall include, but not be limited to the following:

1. Check valves.
2. Three-way valves (of the type that completely closes one side before starting to open the other side).
3. Reverse flow indicators controlling positive shutoff valves.
4. Normally closed air-actuated positive shutoff pressure regulators. [NFPA 54:5.10.2]

1308.11.12 Low-Pressure Protection. A protective device shall be installed between the meter and the appliance
or equipment where the operation of the appliance or equipment is such that it is capable of producing a vacuum or a dangerous reduction in gas pressure at the meter. Such protective devices include, but are not limited to, mechanical, diaphragm-operated, or electrically operated low-pressure shutoff valves. [NFPA 54:5.11]

4208.4 Other Shutoff Valves. Shutoff valves shall be approved and shall be selected giving consideration to pressure drop, service involved, emergency use, and reliability of operation. Shutoff valves of size 1 inch (25 mm) National Pipe Thread and smaller shall be listed. [NFPA 54:5.12]

4208.4 Expansion and Flexibility. Piping systems shall be designed to prevent failure from thermal expansion or contraction. [NFPA 54:5.14.1]

4208.4 Special Local Conditions. Where local conditions include earthquake, tornado, unstable ground, or flood hazards, special consideration shall be given to increased strength and flexibility of piping supports and connections. [NFPA 54:5.14.2]

1309.0 Excess Flow Valve.

1309.1 General. Where automatic excess flow valves are installed, they shall be listed to CSA Z21.93 and shall be sized and installed in accordance with the manufacturer’s instructions. [NFPA 54:5.13]

1310.0 Gas Piping Installation.

1310.1 Piping Underground. Underground gas piping shall be installed with sufficient clearance from any other underground structure to avoid contact therewith, to allow maintenance, and to protect against damage from proximity to other structures. In addition, underground plastic piping shall be installed with approved sufficient clearance or shall be insulated from any source of heat so as to prevent the heat from impairing the serviceability of the pipe. [NFPA 54:7.1.1]

1310.1.1 Cover Requirements. Underground piping systems shall be installed with a minimum of 12 inches (305 mm) of cover. The minimum cover shall be increased to 18 inches (457 mm) if external damage to the pipe or tubing from external forces is likely to result. Where a minimum of 12 inches (305 mm) of cover cannot be provided, the pipe shall be installed in conduit or bridged (shielded). [NFPA 54:7.1.2.1]

1310.1.2 Trenches. The trench shall be graded so that the pipe has a firm, substantially continuous bearing on the bottom of the trench. [NFPA 54:7.1.2.2]

1310.1.2.1 Backfilling. Where flooding of the trench is done to consolidate the backfill, care shall be exercised to see that the pipe is not floated from its firm bearing on the trench bottom. [NFPA 54:7.1.2.3]

1310.1.3 Protection Against Corrosion. Steel pipe and steel tubing installed underground shall be installed in accordance with Section 1310.1.3.1 through Section 1310.1.3.9. [NFPA 54:7.1.3]

1310.1.3.1 Zinc Coating. Zinc coating (galvanizing) shall not be deemed adequate protection for underground gas piping. [NFPA 54:7.1.3.1]

1310.1.3.2 Underground Piping. Underground piping shall comply with one or more of the following unless approved technical justification is provided to demonstrate that protection is unnecessary:

1. The piping shall be made of corrosion-resistant material that is suitable for the environment in which it will be installed.

2. Pipe shall have a factory-applied, electrically insulating coating. Fittings and joints between sections of coated pipe shall be coated in accordance with the coating manufacturer’s instructions.

3. The piping shall have a cathodic protection system installed, and the system shall be maintained in accordance with Section 1310.1.3.3 or Section 1310.1.3.6. [NFPA 54:7.1.3.2]

1310.1.3.3 Cathodic Protection. Cathodic protection systems shall be monitored by testing and the results shall be documented. The test results shall demonstrate one of the following:

1. A pipe-to-soil voltage of −0.85 volts or more negative is produced, with reference to a saturated copper-copper sulfate half cell.

2. A pipe-to-soil voltage of −0.78 volts or more negative is produced, with reference to a saturated KCl calomel half cell.

3. A pipe-to-soil voltage of −0.80 volts or more negative is produced, with reference to a silver-silver chloride half cell.

4. Compliance with a method described in Appendix D of Title 49 of the Code of Federal Regulations, Part 192. [NFPA 54:7.1.3.3]

1310.1.3.4 Sacrificial Anodes. Sacrificial anodes shall be tested in accordance with the following:

1. Upon installation of the cathodic protection system, except where prohibited by climatic conditions, in which case the testing shall be performed not later than 180 days after the installation of the system.

2. 12 to 18 months after the initial test.

3. Upon successful verification testing in accordance with Section 1310.1.3.4(1) and Section 1310.1.3.4(2), periodic follow-up testing shall be performed at intervals not to exceed 36 months. [NFPA 54:7.1.3.4]

1310.1.3.5 System Failing Tests. Systems failing a test shall be repaired not more than 180 days after the date of the failed testing. The testing schedule shall be restarted as required in Section 1310.1.3.4(1) and Section 1310.1.3.4(2), and the results shall comply with Section 1310.1.3.3. [NFPA 54:7.1.3.5]

1310.1.3.6 Impressed Current Cathodic Protection. Impressed current cathodic protection sys-
1310.1.4 Protection Against Freezing. Where the formation of hydrates or ice is known to occur, piping shall be protected against freezing. [NFPA 54:7.1.4]

1310.1.5 Piping Through Foundation Wall. Underground piping, where installed through the outer foundation or basement wall of a building shall be encased in a protective sleeve or protected by an approved device or method. The space between the gas piping and the sleeve shall be sealed to prevent the possible entrance of water, insects, and rodents. [NFPA 54:7.1.5]

1310.1.6 Piping Underground Beneath Buildings. Where gas piping is installed underground beneath buildings, the piping shall be either of the following:

1. Encased in an approved conduit designed to withstand the imposed loads and installed in accordance with Section 1310.1.6.1 or Section 1310.1.6.2.

2. A piping/encasement system listed for installation according to Section 1310.1.6.3 and 1310.1.6.4.

1310.1.6.1 Conduit with One End Terminating Outdoors. The conduit shall extend into an accessible portion of the building and, at the point where the conduit terminates in the building, the space between the conduit and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. Where the conduit terminates is of a type that retains the full pressure of the pipe, the conduit shall be designed for the same pressure as the pipe. The conduit shall extend at least 4 inches (102 mm) outside the building, be vented outdoors above finished ground level, and be installed so as to prevent the entrance of water and insects. [NFPA 54:7.1.6.1]

1310.1.6.2 Conduit with Both Ends Terminating Indoors. Where the conduit originates and terminates within the same building, the conduit shall originate and terminate in an accessible portion of the building and shall not be sealed. [NFPA 54:7.1.6.2]

1310.1.7 Plastic Piping. Plastic piping shall be installed outdoors, underground only. Exceptions:

1. Plastic piping shall be permitted to terminate aboveground where an anodeless riser is used.

2. Plastic piping shall be permitted to terminate with a wall head adapter aboveground in buildings, including basements, where the plastic piping is inserted in a piping material permitted for use in buildings. [NFPA 54:7.1.7.1]

1310.1.7.1 Connections Between Metallic and Plastic Piping. Connections made between metallic and plastic piping shall be made with fittings conforming to one of the following:

1. ASTM D2513 Category I transition fittings

2. ASTM F1973

3. ASTM F2509 [NFPA 54:7.1.7.2]

1310.1.7.2 Tracer Wire. An electrically continuous corrosion-resistant tracer shall be buried with the plastic pipe to facilitate locating. The tracer shall be one of the following:

1. A product specifically designed for that purpose.

2. Insulated copper conductor not less than 14 AWG.

Where tracer wire is used, access shall be provided from aboveground or one end of the tracer wire or tape shall be brought aboveground at a building wall or riser. [NFPA 54:7.1.7.2.2]

1310.2 CSST Piping Systems. CSST piping systems shall be installed in accordance with this code and the manufacturer’s installation instructions. [NFPA 54:7.1.8]

1310.3 Installation of Aboveground Piping. Piping installed aboveground shall be securely supported and located where it will be protected from physical damage. Where passing through an exterior wall, the piping shall also be protected from corrosion by coating or wrapping with an inert material approved for such applications. The piping shall be sealed around its circumference at the point of the exterior penetration to prevent the entry of water, insects, and rodents. Where piping is encased in a protective pipe sleeve, the annular spaces between the gas piping and the sleeve and between the sleeve and the wall opening shall be sealed. [NFPA 54:7.2.1]

1310.3.1 Protective Coating. Where piping is in contact with a material or an atmosphere corrosive to the piping, the piping and fittings shall be coated with a corrosion-resistant material. Any such coating used on piping or components shall not be considered as adding strength to the system. [NFPA 54:7.2.2]

1310.3.2 Building Structure. The installation of gas piping shall not cause structural stresses within building components to exceed allowable design limits. Approval shall be obtained before any beams or joists are cut or notched. [NFPA 54:7.2.3.1 – 7.2.3.2]
1310.2.2 1310.3.3 Gas Piping to be Sloped. Piping for other than dry gas conditions shall be sloped not less than ¼ inch in 15 feet (1.4 mm/m) to prevent traps. [NFPA 54:7.2.3 7.2.4]

1310.2.2.1310.3.1 Ceiling Locations. Gas piping shall be permitted to be installed in accessible spaces between a fixed ceiling and a dropped ceiling, whether or not such spaces are used as a plenum. Valves shall not be located in such spaces.

Exception: Appliance or equipment shutoff valves required by this code shall be permitted to be installed in accessible spaces containing vented appliances.

1310.2.3 1310.3.4 Prohibited Locations. Gas piping inside any building shall not be installed in or through a clothes chute, chimney or gas vent, dumbwaiter, elevator shaft, or air duct, other than combustion air ducts. [NFPA 54:7.2.4]

Exception: Ducts used to provide ventilation air in accordance with Section 701.0 or to above-ceiling spaces in accordance with Section 4110.2.4.1310.3.1.

4110.2.4 1310.3.5 Hangers, Supports, and Anchors. Piping shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers, or building structural components, approved suitable for the size of piping, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. Piping shall be anchored to prevent undue strains on connected appliances and equipment and shall not be supported by other piping. Pipe hangers and supports shall conform to the requirements of MSS SP-58. [NFPA 54:7.2.4 7.2.6.1]

4110.2.4.1310.3.5.1 Spacing. Spacing of supports in gas piping installations shall not be greater than shown in Table 1310.2.4.1310.3.5.1. Spacing of supports of CSST shall be in accordance with the CSST manufacturer’s instructions. [NFPA 54:7.2.4 7.2.6.2]

<table>
<thead>
<tr>
<th>STEEL PIPE, NOMINAL SIZE OF PIPE (inches)</th>
<th>SPACING OF SUPPORTS (feet)</th>
<th>NOMINAL SIZE OF TUBING SMOOTH-WALL (inches O.D.)</th>
<th>SPACING OF SUPPORTS (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½</td>
<td>6</td>
<td>½</td>
<td>4</td>
</tr>
<tr>
<td>¾ or 1</td>
<td>8</td>
<td>¾ or ¼</td>
<td>6</td>
</tr>
<tr>
<td>½ or larger (horizontal)</td>
<td>10</td>
<td>½ or 1 (horizontal)</td>
<td>8</td>
</tr>
<tr>
<td>¾ or larger (vertical)</td>
<td>Every floor level</td>
<td>1 or larger (vertical)</td>
<td>Every floor level</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm

1310.2.4.2 1310.3.5.2 Expansion and Contraction. Supports, hangers, and anchors shall be installed so as not to interfere with the free expansion and contraction of the piping between anchors. All parts of the supporting system shall be designed and installed so they are not disengaged by movement of the supported piping. [NFPA 54:7.2.3 7.2.4 7.2.6.3]

1310.2.4.3 1310.3.5.3 Piping on Roof Tops. Gas piping installed on the roof surfaces shall be elevated above the roof surface and shall be supported in accordance with Table 1310.2.4.3.1. [NFPA 54:7.2.5 7.2.6.6]

1310.2.5 1310.3.6 Removal of Piping. Where piping containing gas is to be removed, the line shall be first disconnected from sources of gas and then thoroughly purged with air, water, or inert gas before cutting or welding is done.

1310.3.1 1310.3.1310.4 Concealed Piping in Buildings. Gas piping in concealed locations shall be installed in accordance with this section. [NFPA 54:7.3.1]

1310.3.2 1310.3.1310.4.1 Connections. Where gas piping is to be concealed, connections shall be of the following type:

(1) Pipe fittings, such as elbows, tees, couplings, and right/left nipple/couplings.

(2) Joining tubing by brazing (see Section 4108.5.8.2 1308.5.7.1).

(3) Press-connect fittings listed to CSA LC 4 for use in concealed spaces or that have been demonstrated to sustain, without leakage, forces due to temperature expansion or contraction, vibration, or fatigue based on their geographic location, application, or operation.

(4) Where necessary to insert fittings in gas pipe that has been installed in a concealed location, the pipe shall be reconnected by welding, flanges, or the use of a right/left nipple/coupling.

1310.3.2.1310.4.2 Piping in Partitions. Concealed gas piping shall not be located in solid partitions. [NFPA 54:7.3.3]

1310.3.2.4 1310.4.3 Tubing in Partitions. This provision shall not apply to tubing that pierces walls, floors, or partitions. Tubing installed vertically and horizontally inside hollow walls or partitions without protection along its entire concealed length shall meet the following requirements:

(1) A steel striker barrier not less than 0.0508 of an inch (1.3 mm) thick, or equivalent, is installed between the tubing and the finished wall and extends at least 4 inches (102 mm) beyond concealed penetrations of plates, firestops, wall studs, and so on.

(2) The tubing is installed in single runs and is not rigidly secured. [NFPA 54:7.3.4]

1310.3.2.4 1310.4.4 Piping in Floors. In industrial occupancies, gas piping in solid floors such as concrete shall be laid in channels in the floor and covered to permit access to the piping with a minimum of damage to the building. Where piping in floor channels could be
exposed to excessive moisture or corrosive substances, the piping shall be protected in an approved manner. [NFPA 54:7.3.5.1]

Exception: In other than industrial occupancies and where approved by the Authority Having Jurisdiction, gas piping embedded in concrete floor slabs constructed with portland cement shall be surrounded with a minimum of 1/2 inches (38 mm) of concrete and shall not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. All piping, fittings, and risers shall be protected against corrosion in accordance with Section 1308.5.6. Piping shall not be embedded in concrete slabs containing quick-set additives or cinder aggregate. [NFPA 54:7.3.5.2]

4340.4.1310.5 Piping in Vertical Chases. Where gas piping exceeding 5 psi (34 kPa) is located within vertical chases in accordance with Section 1310.5.2(2), the requirements of Section 1310.4(1) and 1310.5.1 through Section 1310.4.3 shall apply. [NFPA 54:7.4]

4340.4.1310.5.1 Pressure Reduction. Where pressure reduction is required in branch connections for compliance with Section 1310.4.3, such reduction shall take place either inside the chase or immediately adjacent to the outside wall of the chase. Regulator venting and downstream overpressure protection shall comply with Section 1308.7.4 and Section 1308.8 through Section 1308.9.4. The regulator shall be accessible for service and repair, and vented in accordance with one of the following:

1. Where the fuel gas is lighter than air, regulators equipped with a vent limiting means shall be permitted to be vented into the chase. Regulators not equipped with a vent limiting means shall be permitted to be vented either directly to the outdoors or to a point within the top 1 foot (305 mm) of the chase.

2. Where the fuel gas is heavier than air, the regulator vent shall be vented only directly to the outdoors. [NFPA 54:7.4.1]

4340.4.21310.5.2 Chase Construction. Chase construction shall comply with local building codes with respect to fire resistance and protection of horizontal and vertical openings. [NFPA 54:7.4.2]

4340.4.31310.5.3 Ventilation. A chase shall be ventilated to the outdoors and only at the top. The opening(s) shall have a minimum free area [in square inches (square meters)] equal to the product of one-half of the maximum pressure in the piping [in pounds per square inch (kilopascals)] times the largest nominal diameter of that piping [in inches (millimeters)], or the cross-sectional area of the chase, whichever is smaller. Where more than one fuel gas piping system is present, the free area for each system shall be calculated and the largest area used. [NFPA 54:7.4.3]

4340.51310.6 Maximum Design Operating Pressure in Buildings. The maximum design operating pressure for any piping systems located inside buildings shall not exceed 5 psi (34 kPa) unless one or more of the following conditions are met:

1. The piping system is joints are welded or brazed.
2. The piping joints are flanged and all pipe-to-flange connections are made by welding or brazing.
3. The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
4. The piping is located inside buildings or separate areas of buildings used exclusively for one of the following:
   a. Industrial processing or heating
   b. Research
   c. Warehousing
   d. Boiler or mechanical rooms
5. The piping is a temporary installation for buildings under construction.
6. The piping serves appliances or equipment used for agricultural purposes.
7. The piping system is an LP-Gas piping system with a design operating pressure greater than 20 psi (138 kPa) and complies with NFPA 58. [NFPA 54:5.5.4]
8. The piping system is an LP-Gas piping system with a design operating pressure greater than 20 psi (138 kPa) and complies with NFPA 58. [NFPA 54:5.5.4]
9. The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
10. The piping is located inside buildings or separate areas of buildings used exclusively for one of the following:
   a. Industrial processing or heating
   b. Research
   c. Warehousing
   d. Boiler or mechanical rooms
11. The piping is a temporary installation for buildings under construction.
12. The piping serves appliances or equipment used for agricultural purposes.
4340.61310.7 Gas Pipe Turns. Changes in direction of gas pipe shall be made by the use of fittings, factory bends, or field bends. [NFPA 54:7.5]

4340.71310.8.1 Metallic Pipe. Metallic pipe bends shall comply with the following:

1. Bends shall be made only with bending tools and procedures intended for that purpose.
2. All bends shall be smooth and free from buckling, cracks, or other evidence of mechanical damage.
3. The longitudinal weld of the pipe shall be near the neutral axis of the bend.
4. Pipe shall not be bent through an arc of more than 90 degrees.
5. The inside radius of a bend shall be not less than six times the outside diameter of the pipe. [NFPA 54:7.5.1]

4340.7.21310.8.2 Plastic Pipe. Plastic pipe bends shall comply with the following:

1. The pipe shall not be damaged, and the internal diameter of the pipe shall not be effectively reduced.
2. Joints shall not be located in pipe bends.
3. The radius of the inner curve of such bends shall not be less than 25 times the inside diameter of the pipe.
(4) Where the piping manufacturer specifies the use of special bending tools or procedures, such tools or procedures shall be used. [NFPA 54:7.5.2]

1310.7.3 1310.8.3 Elbows. Factory-made welding elbows or transverse segments cut therefrom shall have an arc length measured along the crotch of at least 1 inch (25 mm) for pipe sizes 2 inches (50 mm) and larger. [NFPA 54:7.5.3]

1310.8.1 1310.9 Drips and Sediment Traps. For other than dry gas conditions, a drip shall be provided at any point in the line of pipe where condensate could collect. Where required by the Authority Having Jurisdiction or the serving gas supplier, a drip shall also be provided at the outlet of the meter. This drip shall be installed so as to constitute a trap wherein an accumulation of condensate shuts off the flow of gas before it runs back into the meter. [NFPA 54:7.6.1]

1310.8.11 1310.9.1 Location of Drips. All drips shall be installed only in such locations that they are readily accessible to permit cleaning or emptying. A drip shall not be located where the condensate is likely to freeze. [NFPA 54:7.6.2]

1310.8.2 1310.9.2 Sediment Traps. The installation of sediment traps shall be in accordance with Section 1312.9. [NFPA 54:7.6.3]

1310.9.1 1310.10 Outlets. Outlets shall be located and installed in accordance with the following requirements:

1. The outlet fittings or piping shall be securely fastened in place.
2. Outlets shall not be located behind doors.
3. Outlets shall be located far enough from floors, walls, patios, slabs, and ceilings to permit the use of wrenches without straining, bending, or damaging the piping.
4. The unthreaded portion of gas piping outlets shall extend not less than 1 inch (25.4 mm) through finished ceilings or indoor or outdoor walls.
5. The unthreaded portion of gas piping outlets shall extend not less than 2 inches (51 mm) above the surface of floors or outdoor patios or slabs.
6. The provisions of Section 1310.9(4) and Section 1310.10(5) shall not apply to listed quick-disconnect devices of the flush-mounted type or listed gas convenience outlets. Such devices shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:7.7.1.1 – 7.7.1.6]

1310.9.4 1310.10.1 Cap Outlets. Each outlet, including a valve, shall be closed gastight with a threaded plug or cap immediately after installation and shall be left closed until the appliance or equipment is connected thereto. When an appliance or equipment is disconnected from an outlet and the outlet is not to be used again immediately, it shall be capped or plugged gastight.

Exceptions:
1. Laboratory appliances installed in accordance with Section 1312.3.1 shall be permitted.
2. The use of a listed quick-disconnect device with integral shutoff or listed gas convenience outlet shall be permitted. [NFPA 54:7.7.2.1]

1310.9.4.1 1310.10.1.1 Appliance Shutoff Valves. Appliance shutoff valves installed in fireplaces shall be removed and the piping capped gastight where the fireplace is used for solid-fuel burning. [NFPA 54:7.7.2.2]

1310.10 Branch Pipe Connection. When a branch outlet is placed on a main supply line before it is known what size pipe will be connected to it, the outlet shall be of the same size as the line that supplies it. [NFPA 54:7.8]

1310.11 Manual Gas Shutoff Valves. An accessible gas shutoff valve shall be provided upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve shall not be required at the second regulator. [NFPA 54:7.9.1]

1310.11.1 Valves Controlling Multiple Systems. Main gas shutoff valves controlling several gas piping systems shall be readily accessible for operation and installed so as to be protected from physical damage. They shall be marked with a metal tag or other permanent means attached by the installing agency so that the gas piping systems supplied through them can be readily identified. [NFPA 54:7.7.2.1]

1310.11.1.1 Shutoff Valves for Multiple House Lines. In multiple-tenant buildings supplied through a master meter, through one service regulator where a meter is not provided, or where meters or service regulators are not readily accessible from the appliance or equipment location, an individual shutoff valve for each apartment or tenant line shall be provided at a convenient point of general accessibility. In a common system serving a number of individual buildings, shutoff valves shall be installed at each building. [NFPA 54:7.7.2.2]

1310.11.2 Emergency Shutoff Valves. An exterior shutoff valve to permit turning off the gas supply to each building in an emergency shall be provided. The emergency shutoff valves shall be plainly marked as such and their locations posted as required by the Authority Having Jurisdiction. [NFPA 54:7.7.2.3]

1310.11.3 Shutoff Valve for Laboratories. Each laboratory space containing two or more gas outlets installed on tables, benches, or in hoods in educational, research, commercial and industrial occupancies shall have a single shutoff valve through which all such gas outlets are supplied. The shutoff valve shall be accessible, located within the laboratory or adjacent to the laboratory’s egress door, and identified. [NFPA 54:7.7.2.4]

1310.12 Prohibited Devices. No device shall be placed inside, within the interior of gas piping or fittings that reduces where such devices reduce the cross-sectional area or otherwise obstructs the free flow of gas, except where proper allowance in the piping system design has been made for such a device and where approved by the Authority Having Jurisdiction. [NFPA 54:7.107.9]
1310.13 Systems Containing Gas-Air Mixtures Outside the Flammable Range. Where gas-air mixing machines are employed to produce mixtures above or below the flammable range, they shall be provided with stops to prevent adjustment of the mixture to within or approaching the flammable range. [NFPA 54:7.10]


1310.14.1 Required Components. A central premix system with a flammable mixture in the blower or compressor shall consist of the following components:

(1) Gas-mixing machine in the form of an automatic gas-air proportioning device combined with a downstream blower or compressor.

(2) Flammable mixture piping, minimum Schedule 40.

(3) Automatic firecheck(s).

(4) Safety blowout(s) or backfire preventers for systems utilizing flammable mixture lines above 2½ inches (64 mm) nominal pipe size or the equivalent. [NFPA 54:7.11.2]

1310.14.2 Optional Components. The following components shall also be permitted to be utilized in any type of central premix system:

(1) Flowmeter(s)

(2) Flame arrester(s) [NFPA 54:7.12.2]

1310.14.3 Additional Requirements. Gas-mixing machines shall have nonsparking blowers and shall be constructed so that a flashback does not rupture machine casings. [NFPA 54:7.12.3]

1310.14.4 Special Requirements for Mixing Blowers. A mixing blower system shall be limited to applications with minimum practical lengths of mixture piping, limited to a maximum mixture pressure of 10 inches water column (2.5 kPa) and limited to gases containing no more than 10 percent hydrogen.

The blower shall be equipped with a gas-control valve at its air entrance arranged so that gas is admitted to the airstream, entering the blower in proper proportions for correct combustion by the type of burners employed, the said gas-control valve being of either the zero governor or mechanical ratio valve type that controls the gas and air adjustment simultaneously. No valves or other obstructions shall be installed between the blower discharge and the burner or burners. [NFPA 54:7.12.4]

1310.14.5 Installation of Gas-Mixing Machines. Installation of gas-mixing machines shall comply with the following:

(1) The gas-mixing machine shall be located in a well-ventilated area or in a detached building or cutoff room provided with room construction and explosion vents in accordance with sound engineering principles. Such rooms or below-grade installations shall have adequate positive ventilation.

(2) Where gas-mixing machines are installed in well-ventilated areas, the type of electrical equipment shall be in accordance with NFPA 70, for general service conditions unless other hazards in the area prevail. Where gas-mixing machines are installed in small detached buildings or cutoff rooms, the electrical equipment and wiring shall be installed in accordance with NFPA 70 for hazardous locations (Articles 500 and 501, Class I, Division 2).

(3) Air intakes for gas-mixing machines using compressors or blowers shall be taken from outdoors whenever practical.

(4) Controls for gas-mixing machines shall include interlocks and a safety shutoff valve of the manual reset type in the gas supply connection to each machine arranged to automatically shut off the gas supply in the event of high or low gas pressure. Except for open-burner installations only, the controls shall be interlocked so that the blower or compressor stops operating following a gas supply failure. Where a system employs pressurized air, means shall be provided to shut off the gas supply in the event of air failure.

(5) Centrifugal gas-mixing machines in parallel shall be reviewed by the user and equipment manufacturer before installation, and means or plans for minimizing the effects of downstream pulsation and equipment overload shall be prepared and utilized as needed. [NFPA 54:7.12.5.1 – 7.12.5.5]

1310.14.6 Use of Automatic Firechecks, Safety Blowouts, or Backfire Preventers. Automatic firechecks and safety blowouts or backfire preventers shall be provided in piping systems distributing flammable air-gas mixtures from gas-mixing machines to protect the piping and the machines in the event of flashback, in accordance with the following:

(1) Approved automatic firechecks shall be installed upstream as close as practical to the burner inlets following the firecheck manufacturer’s instructions.

(2) A separate manually operated gas valve shall be provided at each automatic firecheck for shutting off the flow of the gas-air mixture through the firecheck after a flashback has occurred. The valve shall be located upstream as close as practical to the inlet of the automatic firecheck.

Caution: These valves shall not be reopened after a flashback has occurred until the firecheck has cooled sufficiently to prevent re-ignition of the flammable mixture and has been reset properly.

(3) A safety blowout or backfiring preventer shall be provided in the mixture line near the outlet of each gas-mixing machine where the size of the piping is larger than 2½ inches (65 mm) NPS, or equivalent, to protect the mixing equipment in the event of an explosion passing through an automatic firecheck. The manufacturer’s instructions shall be followed when installing these devices, particularly after a disc has burst. The discharge from the safety blowout or
backfire preventer shall be located or shielded so that particles from the ruptured disc cannot be directed towards personnel. Wherever there are interconnected installations of gas-mixing machines with safety blowouts or backfire preventers, provision shall be made to keep the mixture from other machines from reaching any ruptured disc opening. Check valves shall not be used for this purpose.

(4) Large-capacity premix systems provided with explosion heads (rupture discs) to relieve excessive pressure in pipelines shall be located at and vented to a safe outdoor location. Provisions shall be provided for automatically shutting off the supply of the gas-air mixture in the event of rupture. [NFPA 54:7.12.6 7.11.6]

1311.0 Electrical Bonding and Grounding.
1311.1 Pipe and Tubing Other than CSST. Each above-ground portion of a gas piping system other than CSST that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping, other than CSST, shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.13.1]

1311.2 Bonding of CSST Gas Piping. CSST gas piping systems, and gas piping systems containing one or more segments of CSST, shall be electrically continuous and bonded to the electrical service grounding electrode system of, where provided, lightning protection grounding electrode system. [NFPA 54:7.13.2 7.12.2]

1311.2.1 Bonding Jumper Connection. The bonding jumper shall connect to a metallic pipe, pipe fitting, or CSST fitting. [NFPA 54:7.13.2.1 7.12.2.1]

1311.2.2 Bonding Jumper Size. The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent. [NFPA 54:7.13.2.2 7.12.2.2]

1311.2.3 Bonding Jumper Length. The length of the jumper between the connection to the gas piping system and the grounding electrode system shall not exceed 75 feet (22 860 mm). Any additional grounding electrodes installed to meet this requirement shall be bonded to the electrical service grounding electrode system or, where provided, lightning protection grounding electrode system. [NFPA 54:7.13.2.3 7.12.2.3]

1311.2.4 Bonding Connections. Bonding connections shall be in accordance with NFPA 70. [NFPA 54:7.13.2.4 7.12.2.4]

1311.2.5 Devices Used for Bonding. Devices used for the bonding connection shall be listed for the application in accordance with UL 467. [NFPA 54:7.13.2.5 7.12.2.5]

1311.3 Arc-Resistant Jacketed CSST. CSST listed with an arc-resistant jacket or coating system in accordance with CSA LC 1 shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST component of a piping system does not have an arc-resistant jacket or coating system, the bonding requirements of Section 1311.2 shall apply. Arc-resistant jacketed CSST shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.12.3]

1311.4 Grounding Conductor of Electrode Prohibited Use. Gas piping shall not be used as a grounding conductor or electrode. [NFPA 54:7.12.4]

1311.5 Lighting Protection System. Where a lightning protection system is installed, the bonding of the gas piping shall be in accordance with NFPA 780. [NFPA 54:7.13.4 7.12.5]

1311.6 Electrical Circuits. Electrical circuits shall not utilize gas piping or components as conductors. Exception: Low-voltage (50V or less) control circuits, ignition circuits, and electronic flame detection device circuits shall be permitted to make use of piping or components as a part of an electric circuit. [NFPA 54:7.14 7.13]

1311.6.1 Electrical Connections. All electrical connections between wiring and electrically operated control devices in a piping system shall conform to the requirements of NFPA 70. [NFPA 54:7.14.1]

1311.7 Safety Control. Any essential safety control depending on electric current as the operating medium shall be of a type that shuts off (fail safe) the flow of gas in the event of current failure. [NFPA 54:7.14.2]

1312.0 Appliance and Equipment Connections to Building Piping.
1312.1 Connecting Appliances and Equipment. Appliances and equipment shall be connected to the building piping in compliance with Section 1312.6 through Section 1312.8 by one of the following:

(1) Rigid metallic pipe and fittings.

(2) Semirigid metallic tubing and metallic fittings. Aluminum alloy tubing shall not be used in exterior locations.

(3) A listed connector in compliance with CSA Z21.24. The connector shall be used in accordance with the manufacturer’s installation instructions and shall be in the same room as the appliance. Only one connector shall be used per appliance.

(4) A listed connector in compliance with CSA Z21.75. Only one connector shall be used per appliance.

(5) CSST where installed in accordance with the manufacturer’s installation instructions. CSST shall connect only to appliances that are fixed in place.

(6) Listed nonmetallic gas hose connectors in accordance with Section 1312.3.

(7) Unlisted gas hose connectors for use in laboratories and educational facilities in accordance with Section 1312.4. [NFPA 54:9.6.1]

1312.1.1 Commercial Cooking Appliances. Connectors used with commercial cooking appliances that are moved for cleaning and sanitation purposes shall be installed in accordance with the connector manufacturer’s...
installation instructions. Such connectors shall be listed in accordance with CSA Z21.69. [NFPA 54:9.6.1.3]

1312.1.2 Restraining Device. Movement of appliances with casters shall be limited by a restraining device installed in accordance with the connector and appliance manufacturer’s installation instructions. [NFPA 54:9.6.1.4]

1312.2 Suspended Low-Intensity Infrared Tube Heaters. Suspended low-intensity infrared tube heaters shall be connected to the building piping system with a connector listed for the application in accordance with CSA Z21.24 as follows:

1. The connector shall be installed in accordance with the tube heater installation instructions, and shall be in the same room as the appliance.
2. Only one connector shall be used per appliance. [NFPA 54:9.6.1.5]

1312.3 Use of Nonmetallic Gas Hose Connectors. Listed gas hose connectors shall be used in accordance with the manufacturer’s installation instructions and in accordance with Section 1312.3.1 or Section 1312.3.2. [NFPA 54:9.6.2]

1312.3.1 Indoor. Indoor gas hose connectors shall be used only to connect laboratory, shop, and ironing appliances requiring mobility during operation and installed in accordance with the following:

1. An appliance shutoff valve shall be installed where the connector is attached to the building piping.
2. The connector shall be of minimum length and shall not extend from one room to another or pass through any walls, partitions, ceilings, or floors.
3. The connector shall not be concealed and shall not exceed 6 feet (1829 mm).

1312.3.2 Outdoor. Where outdoor gas hose connectors are used to connect portable outdoor appliances, the connector shall be listed in accordance with CSA Z21.54 and installed in accordance with the following:

1. An appliance shutoff valve, a listed quick-disconnect device, or a listed gas convenience outlet shall be installed where the connector is attached to the supply piping and in such a manner so as to prevent the accumulation of water or foreign matter.
2. This connection shall be made only in the outdoor area where the appliance is to be used. [NFPA 54:9.6.2(2)]
3. The connector length shall not exceed 15 feet (4572 mm).

1312.4 Injection (Bunsen) Burners. Injection (Bunsen) burners used in laboratories and educational facilities shall be permitted to be connected to the gas supply by an unlisted hose. [NFPA 54:9.6.3]

1312.5 Connection of Portable and Mobile Industrial Appliances. Where portable industrial appliances or appliances requiring mobility or subject to vibration are connected to the building gas piping system by the use of a flexible hose, the hose shall be suitable and safe for the conditions under which it can be used. [NFPA 54:9.6.4.1]

1312.5.1 Swivel Joints or Couplings. Where industrial appliances requiring mobility are connected to the rigid piping by the use of swivel joints or couplings, the swivel joints or couplings shall be suitable for the service required and only the minimum number required shall be installed. [NFPA 54:9.6.4.2]

1312.5.2 Metal Flexible Connectors. Where industrial appliances subject to vibration are connected to the building piping system by the use of all metal flexible connectors, the connectors shall be suitable for the service required. [NFPA 54:9.6.4.3]

1312.5.3 Flexible Connectors. Where flexible connections are used, they shall be of the minimum practical length and shall not extend from one room to another or pass through any walls, partitions, ceilings, or floors. Flexible connections shall not be used in any concealed location. They shall be protected against physical or thermal damage and shall be provided with gas shutoff valves in readily accessible locations in rigid piping upstream from the flexible connections. [NFPA 54:9.6.4.4]

1312.6 Appliance Shutoff Valves and Connections. Each appliance connected to a piping system shall have an accessible, approved manual shutoff valve with a nondisplaceable valve member, or a listed gas convenience outlet. Appliance shutoff valves and convenience outlets shall serve a single appliance only. The shutoff valve shall be located within 6 feet (1829 mm) of the appliance it serves. Where a connector is used, the valve shall be installed upstream of the connector. A union or flanged connection shall be provided downstream from the valve to permit removal of appliance controls. Shutoff valves serving decorative appliances shall be permitted to be installed in fireplaces if listed for such use. [NFPA 54:9.6.5, 9.6.5.1(A)(B)]

Exceptions:

1. Shutoff valves serving decorative appliances in a fireplace shall not be permitted to be accessible located inside or under an appliance within the fireplace firebox except where such appliance is removed without removal of the shutoff valve is listed for such use.

2. Shutoff valves shall be permitted to be accessible located inside wall heaters and wall furnaces listed for recessed installation where necessary maintenance is performed without removal of the shutoff valve.

1312.7 Quick-Disconnect Devices. Quick-disconnect devices used to connect appliances to the building piping shall be listed to CSA Z21.41. Where installed indoors, an approved manual shutoff valve with a nondisplaceable valve member shall be installed upstream of the quick-disconnect device. [NFPA 54:9.6.6 – 9.6.6.2]

1312.8 Gas Convenience Outlets. Appliances shall be permitted to be connected to the building piping by means of a listed gas convenience outlet, in conjunction with a listed appliance connector, installed in accordance with the manufacturer’s installation instructions.

Gas convenience outlets shall be listed in accordance with CSA Z21.90 and installed in accordance with the manufacturer’s installation instructions. [NFPA 54:9.6.7]

1312.9 Sediment Trap. Where a sediment trap is not incorporated as a part of the appliance, a sediment trap shall be
installed downstream of the appliance shutoff valve as close to the inlet of the appliance as practical, but before the flex connector, where used at the time of appliance installation. The sediment trap shall be either a tee fitting with a capped nipple in the bottom outlet, as illustrated in Figure 1312.9, or another device recognized as an effective sediment trap. Illuminating appliances, gas ranges, clothes dryers, decorative appliances for installation in vented fireplaces, gas fireplaces, and outdoor grill cooking appliances shall not be required to be so equipped. [NFPA 54:9.6.8]

![Figure 1312.9](image)

**FIGURE 1312.9**
**METHOD OF INSTALLING A TEE FITTING SEDIMENT TRAP**
[NFPA 54: FIGURE 9.6.8]

**1312.10 Installation of Piping.** Piping shall be installed in a manner not to interfere with inspection, maintenance, or servicing of the appliances. [NFPA 54:9.6.9]

**1312.11 Liquefied Petroleum Gas Facilities and Piping.** Liquefied petroleum gas facilities shall comply with NFPA 58.

**1313.0 Pressure Testing, and Inspection, and Purging.**

**1313.1 Piping Installations.** Prior to acceptance and initial operation, all piping installations shall be visually inspected and pressure tested to determine that the materials, design, fabrication, and installation practices comply with the requirements of this code. [NFPA 54:8.1.1.1]

**1313.1.1 Inspection Requirements.** Inspection shall consist of visual examination, during or after manufacture, fabrication, assembly, or pressure tests. [NFPA 54:8.1.1.2]

**1313.1.2 Repairs and Additions.** Where repairs or additions are made following the pressure test, the affected piping shall be tested. Minor repairs and additions are not required to be pressure tested, provided that the work is inspected and connections are tested with a noncorrosive leak-detecting fluid or other leak-detecting methods approved by the Authority Having Jurisdiction. [NFPA 54:8.1.1.3]

**1313.1.3 New Branches.** Where new branches are installed to new appliance(s), only the newly installed branch(es) shall be required to be pressure tested. Connections between the new piping and the existing piping shall be tested with a noncorrosive leak-detecting fluid or approved leak-detecting methods. [NFPA 54:8.1.1.4]

**1313.1.4 Piping System.** A piping system shall be tested as a complete unit or in sections. Under no circumstances shall a valve in a line be used as a bulkhead between gas in one section of the piping system and test medium in an adjacent section, unless a double block and bleed valve system is installed. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve-closing mechanism, is designed to safely withstand the pressure. [NFPA 54:8.1.1.5]

**1313.1.5 Regulators and Valves.** Regulator and valve assemblies fabricated independently of the piping system in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication. [NFPA 54:8.1.1.6]

**1313.1.6 Test Medium.** The test medium shall be air, nitrogen, carbon dioxide, or an inert gas. OXYGEN SHALL NEVER BE USED Oxygen shall not be used as a test medium. [NFPA 54:8.1.2]

**1313.2 Test Preparation.** Test preparation shall comply with Section 1313.2.1 through Section 1313.2.6.

**1313.2.1 Pipe Joints.** Pipe joints, including welds, shall be left exposed for examination during the test. Exception: Covered or concealed pipe end joints that have been previously tested in accordance with this code. [NFPA 54:8.1.3.1]

**1313.2.2 Expansion Joints.** Expansion joints shall be provided with temporary restraints, if required, for the additional thrust load under test. [NFPA 54:8.1.3.2]

**1313.2.3 Appliances and Equipment.** Appliances and equipment that are not to be included in the test shall be either disconnected from the piping or isolated by blanks, blind flanges, or caps. Flanged joints at which blinds are inserted to blank off other equipment during the test shall not be required to be tested. [NFPA 54:8.1.3.3]

**1313.2.4 Designed for (less than) Operating Pressures Less than Test Pressure.** Where the piping system is connected to appliances or equipment designed for operating pressures of less than the test pressure, such appliances or equipment shall be isolated from the piping system by disconnecting them and capping the outlets. [NFPA 54:8.1.3.4]

**1313.2.5 Designed for (equal to or more than) Operating Pressures Equal to or Greater than Test Pressure.** Where the piping system is connected to appliances or equipment designed for operating pressures equal to or greater than the test pressure, such appliances or equipment shall be isolated from the piping system by closing the individual appliance or equipment shutoff valve(s). [NFPA 54:8.1.3.5]
**1313.2.6 Safety.** All testing of piping systems shall be performed in a manner that protects the safety of employees and the public during the test. [NFPA 54:8.1.3.6]

**1313.3 Test Pressure.** This inspection shall include an air, CO₂, or nitrogen pressure test, at which time the gas piping shall stand a pressure of not less than 10 psi (69 kPa) gauge pressure. Test pressures shall be held for a length of time satisfactory to the Authority Having Jurisdiction but in no case less than 15 minutes with no perceptible drop in pressure. For welded piping, and for piping carrying gas at pressures in excess of 14 inches water column (3.5 kPa) pressure, the test pressure shall be not less than 60 psi (414 kPa) and shall be continued for a length of time satisfactory to the Authority Having Jurisdiction, but in no case for less than 30 minutes. For CSST carrying gas at pressures in excess of 14 inches water column (3.5 kPa) pressure, the test pressure shall be 30 psi (207 kPa) for 30 minutes. These tests shall be made using air, CO₂, or nitrogen pressure and shall be made in the presence of the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder. Test gauges used in conducting test shall be in accordance with Section 1303.3.1 through Section 1303.3.4.

**1313.4 Detection of Leaks and Defects.** The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause. [NFPA 54:8.1.5.1]

**1313.4.1 Detecting Leaks.** The leakage shall be located by means of an approved gas detector, a noncorrosive leak detection fluid, or other approved leak detection methods. [NFPA 54:8.1.5.2]

**1313.4.2 Repair or Replace.** Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested. [NFPA 54:8.1.5.3]

**1313.5 Piping System Leak Test.** Leak checks using fuel gas shall be permitted in piping systems that have been pressure-tested in accordance with Section 1313.0. [NFPA 54:8.2.1]

**1313.5.1 Turning Gas On.** During the process of turning gas on into a system of new gas piping, the entire system shall be inspected to determine that there are no open fittings or ends and that all valves at unused outlets are closed and plugged or capped. [NFPA 54:8.2.2]

**1313.5.2 Leak Check.** Immediately after the gas is turned on into a new system or into a system that has been initially restored after an interruption of service, the piping system shall be checked for leakage. Where leakage is indicated, the gas supply shall be shut off until the necessary repairs have been made. [NFPA 54:8.2.3]

**1313.5.3 Placing Appliances and Equipment in Operation.** Appliances and equipment shall not be placed in operation until after the piping system has been checked for leakage in accordance with Section 1313.5.2; the piping system is purged in accordance with Section 1313.6, and connections to the appliance are checked for leakage. [NFPA 54:8.2.4]

**1313.6 Purging Requirements.** The purging of piping shall be in accordance with Section 1313.6.1 through Section 1313.6.3. [NFPA 54:8.3]

**1313.6.1 Piping Systems Required to be Purged Outdoors.** The purging of piping systems shall be in accordance with Section 1313.6.1.1 through Section 1313.6.1.4 where the piping system meets either of the following:

1. The design operating gas pressure is greater than 2 psig (14 kPag).
2. The piping being purged contains one or more sections of pipe or tubing meeting the size and length criteria of Table 1313.6.1. [NFPA 54:8.3.1]

<table>
<thead>
<tr>
<th>NOMINAL PIPING SIZE (inches)</th>
<th>LENGTH OF PIPING (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2-&lt;3</td>
<td>&gt;10</td>
</tr>
<tr>
<td>3-&lt;4</td>
<td>&gt;15</td>
</tr>
<tr>
<td>4-&lt;6</td>
<td>&gt;10</td>
</tr>
<tr>
<td>6-&lt;8</td>
<td>Any length</td>
</tr>
</tbody>
</table>

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

* CSST EHD size of 6 is equivalent to nominal 2 inches (50 mm) pipe or tubing size.

**1313.6.1.1 Removal from Service.** Where existing gas piping is opened, the section that is opened shall be isolated from the gas supply and the line pressure vented in accordance with Section 1313.6.1.3. Where gas piping meeting the criteria of Table 1313.6.1 is removed from service, the residual fuel gas in the piping shall be displaced with an inert gas. [NFPA 54:8.3.1.1]

**1313.6.1.2 Placing in Operation.** Where gas piping containing air and meeting the criteria of Table 1313.6.1 is placed in operation, the air in the piping shall first be displaced with an inert gas. The inert gas shall then be displaced with fuel gas in accordance with Section 1313.6.1.3. [NFPA 54:8.3.1.2]

**1313.6.1.3 Outdoor Discharge of Purged Gases.** The open end of a piping system being pressure vented or purged shall discharge directly to an outdoor location. Purging operations shall comply with all of the following requirements:

1. The point of discharge shall be controlled with a shutoff valve.
2. The point of discharge shall be located at least 10 feet (3048 mm) from sources of ignition, at least 10 feet (3048 mm) from building openings, and at least 25 feet (7620 mm) from mechanical air intake openings.
1313.6.2 Piping Systems Allowed to be Purged Indoors or Outdoors. The purging of piping systems shall be in accordance with the provisions of Section 1313.6.2.1 where the piping system meets both of the following:

(1) The design operating pressure is 2 psig (14 kPag) or less.

(2) The piping being purged is constructed entirely from pipe or tubing not meeting the size and length criteria of Table 1313.6.1. [NFPA 54:8.3.2]

1313.6.2.1 Purging Procedure. The piping system shall be purged in accordance with one or more of the following:

(1) The piping shall be purged with fuel gas and shall discharge to the outdoors.

(2) The piping shall be purged with fuel gas and shall discharge to the indoors or outdoors through an appliance burner not located in a combustion chamber. Such burner shall be provided with a continuous source of ignition.

(3) The piping shall be purged with fuel gas and shall discharge to the indoors or outdoors through a burner that has a continuous source of ignition and that is designed for such purpose.

(4) The piping shall be purged with fuel gas that is discharged to the indoors or outdoors, and the point of discharge shall be monitored with a listed combustible gas detector in accordance with Section 1313.6.2.2. Purging shall be stopped when fuel gas is detected.

(5) The piping shall be purged by the gas supplier in accordance with written procedures. [NFPA 54:8.3.2.1]

1313.6.2.2 Combustible Gas Detector. Combustible gas detectors shall be listed and calibrated or tested in accordance with the manufacturer’s instructions. Combustible gas detectors shall be capable of indicating the presence of fuel gas. [NFPA 54:8.3.2.2]

1313.6.3 Purging Appliances and Equipment. After the piping system has been placed in operation, appliances and equipment shall be purged before being placed into operation. [NFPA 54:8.3.3]

1314.0 Required Gas Supply.

1314.1 General. The following regulations, shall comply with this section and Section 1315.0, shall be the standard for the installation of gas piping. Natural gas regulations and tables are based on the use of gas having a specific gravity of 0.60 and for undiluted liquefied petroleum gas having a specific gravity of 1.50.

Where gas of a different specific gravity is to be delivered, the serving gas supplier shall be permitted to be contacted for specific gravity conversion factors to use in sizing piping systems from the size piping tables in this chapter.

1314.2 Volume. The hourly volume of gas required at each piping outlet shall be taken as not less than the maximum hourly rating as specified by the manufacturer of the appliance or appliances to be connected to each such outlet.

1314.3 Gas Appliances. Where the gas appliances to be installed have not been definitely specified, Table 1308.4.1 shall be permitted to be used as a reference to estimate requirements of typical appliances. To obtain the cubic feet per hour (m³/h) of gas required, divide the input of the appliances by the average Btu (kW•h) heating value per cubic foot (m³) of the gas. The average Btu (kW•h) per cubic foot (m³) of the gas in the area of the installation shall be permitted to be obtained from the serving gas supplier.

1314.4 Size of Piping Outlets. The size of the supply piping outlet for a gas appliance shall be not less than ½ of an inch (15 mm).

The size of a piping outlet for a mobile home shall be not less than ¾ of an inch (20 mm).

1315.0 Required Gas Piping Size.

1315.1 Pipe Sizing Methods. Where the pipe size is to be determined using a method in Section 1315.1.1 through Section 1315.1.3, the diameter of each pipe segment shall be obtained from the pipe sizing tables in Section 1315.2 or from the sizing equations in Section 1315.3. [NFPA 54:6.1]

1315.1.1 Longest Length Method. The pipe size of each section of gas piping shall be determined using the longest length of piping from the point of delivery to the most remote outlet and the load of the section. [NFPA 54:6.1.1]

1315.1.2 Branch Length Method. Pipe shall be sized as follows:

(1) The pipe size of each section of the longest pipe run from the point of delivery to the most remote outlet shall be determined using the longest run of piping and the load of the section.

(2) The pipe size of each section of branch piping not previously sized shall be determined using the
length of piping from the point of delivery to the most remote outlet in each branch and the load of the section. [NFPA 54:6.1.2]

1315.1.3 Hybrid Pressure. The pipe size for each section of higher pressure gas piping shall be determined using the longest length of piping from the point of delivery to the most remote line pressure regulator. The pipe size from the line pressure regulator to each outlet shall be determined using the length of piping from the regulator to the most remote outlet served by the regulator. [NFPA 54:6.1.3]

1315.2 Tables for Sizing Gas Piping Systems. Table 1315.2(1) through Table 1315.2(26) shall be used to size gas piping in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3. [NFPA 54:6.2]

1315.2 Sizing of Gas Piping Systems. Sizing of piping systems shall be in accordance with Section 1315.2.1 for natural gas piping system and Section 1315.2.2 for propane piping systems.

1315.2.1 Natural Gas Piping Systems. Table 1315.2(1) through Table 1315.2(23) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for piping materials other than non-corrugated stainless steel tubing. Section 1315.3 shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.2.1, 6.2.2]

1315.2.2 Propane Piping Systems. Table 1315.2(24) through Table 1315.2(36) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for piping materials other than non-corrugated stainless steel tubing. Section 1315.3 shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.3.1, 6.3.2]

1315.3 Sizing Equations. The inside diameter of smooth wall pipe or tubing shall be determined by Equation 1315.3(1), Equation 1315.3(2), Table 1315.3, and using the equivalent pipe length determined by the methods in Section 1315.1.1 through Section 1315.1.3. [NFPA 54:6.4]

LOW-PRESSURE GAS FORMULA (LESS THAN 1.5 psi (10.3 kPa)) [NFPA 54:6.4.1]

\[
D = \frac{Q^{0.381}}{19.17 \left( \frac{\Delta H}{Cr \times L} \right)^{0.206}}
\]

[Equation 1315.3(1)]

Where:
- \( D \) = inside diameter of pipe, inches
- \( Q \) = input rate appliance(s), cubic feet per hour at 60°F and 30 inch mercury column
- \( L \) = equivalent length of pipe, feet
- \( \Delta H \) = pressure drop, inches of water column
- \( Cr \) = in accordance with Table 1315.3

HIGH-PRESSURE GAS FORMULA (1.5 psi (10.3 kPa) AND ABOVE) [NFPA 54:6.4.2]

\[
D = \frac{Q^{0.381}}{18.93 \left( \frac{(P_1^2 - P_2^2) \times Y}{Cr \times L} \right)^{0.206}}
\]

[Equation 1315.3(2)]

Where:
- \( D \) = inside diameter of pipe, inches
- \( Q \) = input rate appliance(s), cubic feet per hour at 60°F and 30 inch mercury column
- \( P_1 \) = upstream pressure, psia \((P_1 + 14.7)\)
- \( P_2 \) = downstream pressure, psia \((P_2 + 14.7)\)
- \( L \) = equivalent length of pipe, feet
- \( Cr \) = in accordance with Table 1315.3
- \( Y \) = in accordance with Table 1315.3

For SI units: 1 cubic foot = 0.0283 m³, 1000 British thermal units per hour = 0.293 kW, 1 inch = 25 mm, 1 foot = 304.8 mm, 1 pound-force per square inch = 6.8947 kPa, °C = (°F-32)/1.8, 1 inch mercury column = 3.39 kPa, 1 inch water column = 0.249 kPa

TABLE 1315.3

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<th>FORMULA FACTORS</th>
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<tr>
<td>Undiluted Propane</td>
<td>1.2462</td>
</tr>
</tbody>
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1315.4 Sizing of Piping Sections. To determine the size of each section of pipe in a system within the range of Table 1315.2(1) through Table 1315.2(36), proceed as follows:

1. Measure the length of the pipe from the gas meter location to the most remote outlet on the system.
2. Select the length in feet column and row showing the distance, or the next longer distance where the table does not give the exact length.
3. Starting at the most remote outlet, find in the just selected section of branch piping not previously sized by the methods described in Section 1315.1.1 through Table 1315.2(23) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.4.1]

1315.4 Sizing of Piping Sections. To determine the size of each section of pipe in a system within the range of Table 1315.2(1) through Table 1315.2(36), proceed as follows:

1. Measure the length of the pipe from the gas meter location to the most remote outlet on the system.
2. Select the length in feet column and row showing the distance, or the next longer distance where the table does not give the exact length.
3. Starting at the most remote outlet, find in the just selected section of branch piping not previously sized by the methods described in Section 1315.1.1 through Table 1315.2(23) shall be used in conjunction with one of the methods described in Section 1315.1.1 through Section 1315.1.3 for non-corrugated stainless steel tubing. [NFPA 54:6.4.1]
most remote outlet in that branch and follow the procedures of steps 2, 3, 4, and 5 above. Size branch piping in the order of their distance from the meter location, beginning with the most distant outlet not previously sized.

1315.5 Engineering Methods. For conditions other than those covered by Section 1315.1, such as longer runs or greater gas demands, the size of each gas piping system shall be determined by standard engineering methods acceptable to the Authority Having Jurisdiction, and each such system shall be so designed that the total pressure drop between the meter or other point of supply and an outlet where full demand is being supplied to outlets, shall be in accordance with the requirements of Section 1308.4.

1315.6 Variable Gas Pressures. Where the supply gas pressure exceeds 5 psi (34 kPa) for natural gas and 10 psi (69 kPa) for undiluted propane or is less than 6 inches (1.5 kPa) of water column, or where diversity demand factors are used, the design, pipe, sizing, materials, location, and use of such systems first shall be approved by the Authority Having Jurisdiction. Piping systems designed for pressures exceeding the serving gas supplier’s standard delivery pressure shall have prior verification from the gas supplier of the availability of the design pressure.
**FIGURE 1315.1.1**
EXAMPLE ILLUSTRATING USE OF TABLE 1308.4.1 AND TABLE 1315.2(1)

**Problem:** Determine the required pipe size of each section and outlet of the piping system shown in Figure 1315.1.1. Gas to be used has a specific gravity of 0.60 and 1100 British thermal units (Btu) per cubic foot (0.0114 kW•h/L), delivered at 8 inch water column (1.9 kPa) pressure.

**Solution:**

1. Maximum gas demand of Outlet A —
   - 32 cubic feet per hour (0.91 m³/h) (from Table 1308.4.1).
   - Maximum gas demand of Outlet B —
     - 3 cubic feet per hour (0.08 m³/h) (from Table 1308.4.1).
   - Maximum gas demand of Outlet C —
     - 59 cubic feet per hour (1.67 m³/h) (from Table 1308.4.1).
   - Maximum gas demand of Outlet D —
     - 136 cubic feet per hour (3.85 m³/h) [150 000 Btu/hour (44 kW)] divided by 1100 Btu per cubic foot (0.0114 kW•h/L)

2. The length of pipe from the gas meter to the most remote outlet (Outlet A) is 60 feet (18 288 mm).

3. Using the length in feet column row marked 60 feet (18 288 mm) in Table 1315.2(1):
   - Outlet A, supplying 32 cubic feet per hour (0.91 m³/h), requires ½ of an inch (15 mm) pipe.
   - Section 1, supplying Outlets A and B, or 35 cubic feet per hour (0.99 m³/h) requires ½ of an inch (15 mm) pipe.
   - Section 2, supplying Outlets A, B, and C, or 94 cubic feet per hour (2.66 m³/h) requires ⅜ of an inch (20 mm) pipe.
   - Section 3, supplying Outlets A, B, C, and D, or 230 cubic feet per hour (6.51 m³/h), requires 1 inch (25 mm) pipe.

4. Using the column marked 60 feet (18 288 mm) in Table 1315.2(1) [no column for actual length of 55 feet (16 764 mm)]:
   - Outlet B supplying 3 cubic feet per hour (0.08 m³/h), requires ½ of an inch (15 mm) pipe.
   - Outlet C, supplying 59 cubic feet per hour (1.67 m³/h), requires ½ of an inch (15 mm) pipe.
   - Using the column marked 60 feet (18 288 mm) in Table 1315.2(1):
     - Outlet D, supplying 136 cubic feet per hour (3.85 m³/h), requires ¾ of an inch (20 mm) pipe.
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<th>PIPE SIZE (inch)</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
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GAS: NATURAL
INLET PRESSURE: LESS THAN 2 psi
PRESSURE DROP: 0.5 in. w.c.
SPECIFIC GRAVITY: 0.60

Notes:
1 Table entries are rounded to 3 significant digits.
2 NA means a flow of less than 10 ft³/h (0.283 m³/h).

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

TABLE 1315.2(1)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2.1(b)]¹²

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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa
FUEL GAS PIPING

TABLE 1315.2(2)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2.1(c)]*

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<table>
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<tr>
<th>LENGTH (feet)</th>
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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa
* Table entries are rounded to 3 significant digits.
### TABLE 1315.2(3)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2.1(d)***

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<td>125</td>
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<td>2150</td>
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<td>7760</td>
</tr>
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<td>104</td>
<td>195</td>
<td>400</td>
<td>600</td>
<td>1160</td>
<td>1840</td>
<td>3260</td>
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<td>384</td>
<td>575</td>
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<td>95</td>
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<td>552</td>
<td>1060</td>
<td>1690</td>
<td>3000</td>
<td>6110</td>
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<tr>
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<td>44</td>
<td>92</td>
<td>173</td>
<td>355</td>
<td>532</td>
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<td>1630</td>
<td>2890</td>
<td>5890</td>
</tr>
<tr>
<td>1600</td>
<td>42</td>
<td>89</td>
<td>167</td>
<td>343</td>
<td>514</td>
<td>989</td>
<td>1580</td>
<td>2790</td>
<td>5680</td>
</tr>
<tr>
<td>1700</td>
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<td>332</td>
<td>497</td>
<td>957</td>
<td>1530</td>
<td>2700</td>
<td>5500</td>
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<td>322</td>
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<td>928</td>
<td>1480</td>
<td>2610</td>
<td>5330</td>
</tr>
<tr>
<td>1900</td>
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<td>81</td>
<td>152</td>
<td>312</td>
<td>468</td>
<td>901</td>
<td>1440</td>
<td>2540</td>
<td>5180</td>
</tr>
<tr>
<td>2000</td>
<td>38</td>
<td>79</td>
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<td>304</td>
<td>455</td>
<td>877</td>
<td>1400</td>
<td>2470</td>
<td>5040</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

* Table entries are rounded to 3 significant digits.
### FUEL GAS PIPING

**TABLE 1315.2(4)**

**SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2.1(e)]**

<table>
<thead>
<tr>
<th>GAS: NATURAL</th>
<th>INLET PRESSURE:</th>
<th>2.0 psi</th>
<th>PRESSURE DROP:</th>
<th>1.0 psi</th>
<th>SPECIFIC GRAVITY:</th>
<th>0.60</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>ACTUAL ID:</th>
<th>0.622</th>
<th>0.824</th>
<th>1.049</th>
<th>1.380</th>
<th>1.610</th>
<th>2.067</th>
<th>2.469</th>
<th>3.068</th>
<th>4.026</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH (feet)</td>
<td>CAPACITY IN CUBIC FEET OF GAS PER HOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1510</td>
<td>3040</td>
<td>5560</td>
<td>11 400</td>
<td>17 100</td>
<td>32 900</td>
<td>52 500</td>
<td>92 800</td>
<td>189 000</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1070</td>
<td>2150</td>
<td>3930</td>
<td>8070</td>
<td>12 100</td>
<td>23 300</td>
<td>37 100</td>
<td>65 600</td>
<td>134 000</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>869</td>
<td>1760</td>
<td>3210</td>
<td>6590</td>
<td>9880</td>
<td>19 000</td>
<td>30 300</td>
<td>53 600</td>
<td>109 000</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>753</td>
<td>1520</td>
<td>2780</td>
<td>5710</td>
<td>8550</td>
<td>16 500</td>
<td>26 300</td>
<td>46 400</td>
<td>94 700</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>673</td>
<td>1360</td>
<td>2490</td>
<td>5110</td>
<td>7650</td>
<td>14 700</td>
<td>23 000</td>
<td>41 500</td>
<td>84 700</td>
<td></td>
</tr>
</tbody>
</table>

* Table entries are rounded to 3 significant digits.

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

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### Table 1315.2(5)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2.1(f)]

<table>
<thead>
<tr>
<th>GAS: NATURAL</th>
<th>INLET PRESSURE: 3.0 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE DROP: 2.0 psi</td>
<td></td>
</tr>
<tr>
<td>SPECIFIC GRAVITY: 0.60</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual ID</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>0.622</td>
</tr>
<tr>
<td>4</td>
<td>0.60</td>
</tr>
<tr>
<td>5</td>
<td>0.60</td>
</tr>
<tr>
<td>6</td>
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<td>7</td>
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<td>8</td>
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</tr>
<tr>
<td>9</td>
<td>0.60</td>
</tr>
<tr>
<td>10</td>
<td>0.60</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

* Table entries are rounded to 3 significant digits.
**FUEL GAS PIPING**

**TABLE 1315.2(6)**

**SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2.1]**

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>ACTUAL ID</th>
<th>NOMINAL</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH (feet)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.822</td>
<td>0.824</td>
<td>1.049</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>3.068</td>
</tr>
<tr>
<td>30</td>
<td>1.610</td>
<td></td>
<td>2.469</td>
</tr>
<tr>
<td>40</td>
<td>2.067</td>
<td></td>
<td>3.068</td>
</tr>
<tr>
<td>50</td>
<td>1.380</td>
<td></td>
<td>4.026</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

* Table entries are rounded to 3 significant digits.
TABLE 1315.2(7)
SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2.1(h)]\(^1,2\)

<table>
<thead>
<tr>
<th>TUBE SIZE (inch)</th>
<th>K &amp; L:</th>
<th>ACR:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>½</td>
<td>½</td>
</tr>
<tr>
<td>OUTSIDE:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.375</td>
<td>0.500</td>
<td>0.625</td>
</tr>
<tr>
<td>INSIDE:</td>
<td>0.305</td>
<td>0.402</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LENGTH (feet)</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>42</td>
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<tr>
<td>30</td>
<td>11</td>
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<td>NA</td>
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<td>NA</td>
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<td>NA</td>
</tr>
<tr>
<td>1900</td>
<td>NA</td>
</tr>
<tr>
<td>2000</td>
<td>NA</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m\(^3\)/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

Notes:
1. Table entries are rounded to 3 significant digits.
2. NA means a flow of less than 10 ft\(^3\)/h (0.283 m\(^3\)/h).
3. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
### TABLE 1315.2(8)

**SEMI-RIGID COPPER TUBING** [NFPA 54: TABLE 6.2.1(8)]

<table>
<thead>
<tr>
<th>TUBE SIZE (inch)</th>
<th>GAS: NATURAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL:</td>
<td>INLET PRESSURE: LESS THAN 2 psi</td>
</tr>
<tr>
<td>K &amp; L:</td>
<td>⅛</td>
</tr>
<tr>
<td>ACR:</td>
<td>%</td>
</tr>
<tr>
<td>OUTSIDE:</td>
<td>30</td>
</tr>
<tr>
<td>INSIDE:¹²</td>
<td>0.305</td>
</tr>
<tr>
<td>LENGTH (feet)</td>
<td>10</td>
</tr>
<tr>
<td>CAPACITY IN CUBIC FEET OF GAS PER HOUR</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>590</td>
</tr>
<tr>
<td></td>
<td>1680</td>
</tr>
<tr>
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<td>3490</td>
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<td>1680</td>
</tr>
<tr>
<td></td>
<td>3490</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>590</td>
</tr>
<tr>
<td></td>
<td>1680</td>
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<td></td>
<td>3490</td>
</tr>
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<td>10</td>
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<td>1680</td>
</tr>
<tr>
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<td>3490</td>
</tr>
<tr>
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<td>10</td>
</tr>
<tr>
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<td>111</td>
</tr>
<tr>
<td></td>
<td>590</td>
</tr>
<tr>
<td></td>
<td>1680</td>
</tr>
<tr>
<td></td>
<td>3490</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

Notes:

1. Table entries are rounded to 3 significant digits.
2. NA means a flow of less than 10 ft³/h (0.283 m³/h).
3. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
<table>
<thead>
<tr>
<th>Length (feet)</th>
<th>Capacity in Cubic Feet of Gas per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>39 80 162 283 402 859 1550 2440 5080</td>
</tr>
<tr>
<td>20</td>
<td>27 55 111 195 276 390 700 1200 2400</td>
</tr>
<tr>
<td>30</td>
<td>21 44 89 156 222 300 540 1440 2880</td>
</tr>
<tr>
<td>40</td>
<td>18 38 77 134 190 240 390 720 1440</td>
</tr>
<tr>
<td>50</td>
<td>16 33 68 119 168 240 390 720 1440</td>
</tr>
<tr>
<td>60</td>
<td>15 30 61 107 152 300 800 1600 3200</td>
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<tr>
<td>70</td>
<td>13 28 57 99 140 300 540 1440 2880</td>
</tr>
<tr>
<td>80</td>
<td>13 26 53 92 131 290 580 1160 2320</td>
</tr>
<tr>
<td>90</td>
<td>12 24 49 86 122 260 445 890 1780</td>
</tr>
<tr>
<td>100</td>
<td>11 23 47 82 116 240 445 890 1780</td>
</tr>
</tbody>
</table>

Notes:
1. Table entries are rounded to 3 significant digits.
2. NA means a flow of less than 10 ft³/h (0.283 m³/h).
3. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
### TABLE 1315.2(10)
**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2.1(k)]²**

<table>
<thead>
<tr>
<th>NOMINAL:</th>
<th>K &amp; L:</th>
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<th>¼</th>
<th>¼</th>
<th>¼</th>
<th>¼</th>
<th>½</th>
<th>1</th>
<th>1¼</th>
<th>1½</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC#:</td>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>OUTSIDE:</td>
<td></td>
<td>0.375</td>
<td>0.500</td>
<td>0.625</td>
<td>0.750</td>
<td>0.875</td>
<td>1.125</td>
<td>1.375</td>
<td>1.625</td>
<td>2.125</td>
<td></td>
</tr>
<tr>
<td>INSIDE:</td>
<td></td>
<td>0.305</td>
<td>0.402</td>
<td>0.527</td>
<td>0.652</td>
<td>0.745</td>
<td>0.995</td>
<td>1.245</td>
<td>1.481</td>
<td>1.959</td>
<td></td>
</tr>
<tr>
<td>LENGTH (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>10</td>
<td>190</td>
<td>391</td>
<td>796</td>
<td>1390</td>
<td>1970</td>
<td>4220</td>
<td>7590</td>
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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

Notes:
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Table entries are rounded to 3 significant digits.
### TABLE 1315.2(11)
**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2.1(1)]**

| TUBE SIZE (inch) | NOMINAL: | OUTSIDE: | INSIDE: | K & L | ACR | ¼ | ½ | ¾ | 1 | 1½ | 1¼ | 1¾ | 2 |
|------------------|----------|----------|---------|------|-----|----|---|---|---|----|----|----|---|---|
| LENGTH (feet)    | CAPACITY IN CUBIC FEET OF GAS PER HOUR |          |         |      |     |    |   |   |   |    |    |    |   |   |
| 10               | 245      | 506      | 1030    | 1800 | 2550| 5450| 9820| 15500| 32200|
| 20               | 169      | 348      | 708     | 1240 | 1760| 3750| 6750| 10600| 22200|
| 30               | 135      | 279      | 568     | 993  | 1410| 3010| 5420| 8550  | 17800 |
| 40               | 116      | 239      | 486     | 850  | 1210| 2580| 4640| 7310  | 15200 |
| 50               | 103      | 212      | 431     | 754  | 1070| 2280| 4110| 6480  | 13500 |
| 60               | 93       | 192      | 391     | 683  | 969 | 2070| 3730| 5870  | 12200 |
| 70               | 86       | 177      | 359     | 628  | 891 | 1900| 3430| 5400  | 11300 |
| 80               | 80       | 164      | 334     | 584  | 829 | 1770| 3190| 5030  | 10500 |
| 90               | 75       | 154      | 314     | 548  | 778 | 1660| 2990| 4720  | 9820  |
| 100              | 71       | 146      | 296     | 518  | 735 | 1570| 2830| 4450  | 9280  |
| 125              | 63       | 129      | 263     | 459  | 651 | 1390| 2500| 3950  | 8220  |
| 150              | 57       | 117      | 238     | 416  | 590 | 1260| 2270| 3580  | 7450  |
| 175              | 52       | 108      | 219     | 363  | 543 | 1160| 2090| 3290  | 6850  |
| 200              | 49       | 100      | 204     | 356  | 505 | 1080| 1940| 3060  | 6380  |
| 250              | 43       | 89       | 181     | 315  | 448 | 956 | 1720| 2710  | 5650  |
| 300              | 39       | 80       | 164     | 286  | 406 | 866 | 1560| 2460  | 5120  |
| 350              | 36       | 74       | 150     | 263  | 373 | 797 | 1430| 2260  | 4710  |
| 400              | 33       | 69       | 140     | 245  | 347 | 741 | 1330| 2100  | 4380  |
| 450              | 31       | 65       | 131     | 230  | 326 | 696 | 1250| 1970  | 4110  |
| 500              | 30       | 61       | 124     | 217  | 308 | 657 | 1180| 1870  | 3880  |
| 550              | 28       | 58       | 118     | 206  | 292 | 624 | 1120| 1770  | 3690  |
| 600              | 27       | 55       | 112     | 196  | 279 | 595 | 1070| 1690  | 3520  |
| 650              | 26       | 53       | 108     | 188  | 267 | 570 | 1030| 1620  | 3370  |
| 700              | 25       | 51       | 103     | 181  | 256 | 548 | 986 | 1550  | 3240  |
| 750              | 24       | 49       | 100     | 174  | 247 | 528 | 950 | 1500  | 3120  |
| 800              | 23       | 47       | 96      | 168  | 239 | 510 | 917 | 1450  | 3010  |
| 850              | 22       | 46       | 93      | 163  | 231 | 493 | 888 | 1400  | 2920  |
| 900              | 22       | 44       | 90      | 158  | 224 | 478 | 861 | 1360  | 2830  |
| 950              | 21       | 43       | 88      | 153  | 217 | 464 | 836 | 1320  | 2740  |
| 1000             | 20       | 42       | 85      | 149  | 211 | 452 | 813 | 1280  | 2670  |
| 1100             | 19       | 40       | 81      | 142  | 201 | 429 | 772 | 1220  | 2540  |
| 1200             | 18       | 38       | 77      | 135  | 192 | 409 | 737 | 1160  | 2420  |
| 1300             | 18       | 36       | 74      | 129  | 183 | 392 | 705 | 1110  | 2320  |
| 1400             | 17       | 35       | 71      | 124  | 176 | 376 | 678 | 1070  | 2230  |
| 1500             | 16       | 34       | 68      | 120  | 170 | 363 | 653 | 1030  | 2140  |
| 1600             | 16       | 33       | 66      | 116  | 164 | 350 | 630 | 994   | 2070  |
| 1700             | 15       | 31       | 64      | 112  | 159 | 339 | 610 | 962   | 2000  |
| 1800             | 15       | 30       | 62      | 108  | 154 | 329 | 592 | 933   | 1940  |
| 1900             | 14       | 30       | 60      | 105  | 149 | 319 | 575 | 906   | 1890  |
| 2000             | 14       | 29       | 59      | 102  | 145 | 310 | 559 | 881   | 1830  |

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

**Notes:**
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Table entries are rounded to 3 significant digits.
### Table 1315.2(12)
**Semi-Rigid Copper Tubing [NFPA 54: Table 6.2.1(m)]**

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<th>Inside</th>
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<td>4/3</td>
<td>3/4</td>
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<td>3/4</td>
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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

**Notes:**
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Where this table is used to size the tubing upstream of a line pressure regulator, the pipe or tubing downstream of the line pressure regulator shall be sized using a pressure drop no greater than 1 inch water column (0.249 kPa).
3. Table entries are rounded to 3 significant digits.
# TABLE 1315.2(13)
## SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2.1(n)]²

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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

Notes:
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Table entries are rounded to 3 significant digits.
**FUEL GAS PIPING**

**TABLE 1315.2(14)**
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2.1(0)]

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

**Notes:**
1. Table entries are rounded to 3 significant digits.
2. Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: \( L = 1.3n \), where \( L \) is additional length (ft) of tubing and \( n \) is the number of additional fittings, bends, or both.
3. EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa
TABLE 1315.2(15)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2.1(p)]\(^1,2\)

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</table>

For SI units: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

Notes:
1 Table entries are rounded to 3 significant digits.
2 Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: \( L = 1.3n \), where \( L \) is additional length (ft) of tubing and \( n \) is the number of additional fittings, bends, or both.
3 EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
### Table 1315.2(16)
**CORRUGATED STAINLESS STEEL TUBING (CSST)** [NFPA 54: TABLE 6.2.1(q)]<sup>1,2</sup>

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<th>TABLE 1315.2(16)</th>
<th>CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2.1(q)]&lt;sup&gt;1,2&lt;/sup&gt;</th>
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**TABLE 1315.2(16)**

**CORRUGATED STAINLESS STEEL TUBING (CSST)**

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<th>GAS: NATURAL</th>
<th>INLET PRESSURE: LESS THAN 2 psi</th>
<th>PRESSURE DROP: 6.0 in. w.c.</th>
<th>SPECIFIC GRAVITY: 0.60</th>
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**INTENDED USE: INITIAL SUPPLY PRESSURE OF 11.0 INCH WATER COLUMN OR GREATER**

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<th>FLOW DESIGNATION:</th>
<th>TUBE SIZE (EHD)&lt;sup&gt;3&lt;/sup&gt;</th>
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</table>

For SI units: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

**Notes:**

1. Table entries are rounded to 3 significant digits.
2. Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: \( L = 1.3 \, n \), where \( L \) is additional length (ft) of tubing and \( n \) is the number of additional fittings, bends, or both.
3. EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
### Table 1315.2(17)

**Corrugated Stainless Steel Tubing (CSST) [NFPA 54: Table 6.2.1](r)\(^1\), \(^2\), \(^3\), \(^4\)**

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</tr>
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</table>

For SI units: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

**Notes:**

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 0.75 psi (5.17 kPa), DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator are capable of varying with flow rate.
2. CAUTION: Capacities shown in table are capable of exceeding maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.
3. Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing according to the following equation: \( L = 1.3n \), where \( L \) is additional length (ft) of tubing and \( n \) is the number of additional fittings, bends, or both.
4. Table entries are rounded to 3 significant digits.
5. EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
### TABLE 1315.2(18)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2.1(1)]

| Flow Designation | 13  | 15  | 18  | 19  | 23  | 25  | 30  | 31  | 37  | 46  | 48  | 60  | 62  |
|------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| Length (feet)    | 10 | 25 | 30 | 40 | 50 | 75 | 80 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| Capacity in Cubic Feet of Gas per Hour | | | | | | | | | | | | | | |

For SI units: 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

**Notes:**
1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 1 psi (7 kPa), DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across regulator are capable of varying with the flow rate.
2. CAUTION: Capacities shown in table are capable of exceeding the maximum capacity of selected regulator. Consult tubing manufacturer for guidance.
3. Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: 
   \[ L = 1.3n \]
   where \( L \) is additional length (feet) of tubing and \( n \) is the number of additional fittings, bends, or both.
4. Table entries are rounded to 3 significant digits.
5. EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
TABLE 1315.2(19)
POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.2.1(1)]*

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>NOMINAL OD</th>
<th>ACTUAL ID</th>
<th>LENGTH (feet)</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1⁄2</td>
<td>3⁄4</td>
<td>1</td>
<td>1 1⁄8</td>
</tr>
<tr>
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<td>SDR 11</td>
<td>SDR 11</td>
<td>SDR 10</td>
</tr>
<tr>
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<td>0.660</td>
<td>0.860</td>
<td>1.077</td>
<td>1.328</td>
</tr>
<tr>
<td>INLET PRESSURE</td>
<td>LESS THAN 2 psi</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PRESSURE DROP</td>
<td>0.3 in. w.c.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPECIFIC GRAVITY</td>
<td>0.60</td>
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<td></td>
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</tr>
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</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

* Table entries are rounded to 3 significant digits.
TABLE 1315.2(20)
POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.2.1(u)]

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<th>⅝</th>
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<th>1 ⅜</th>
<th>1 ⅝</th>
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<th>3</th>
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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa
* Table entries are rounded to 3 significant digits.
### TABLE 1315.2(21)
POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.2.1(v)]

<table>
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<th>GAS:</th>
<th>NATURAL</th>
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<td>INLET PRESSURE:</td>
<td>2.0 psi</td>
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<tr>
<td>PRESSURE DROP:</td>
<td>1.0 psi</td>
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<tr>
<td>SPECIFIC GRAVITY:</td>
<td>0.60</td>
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</tbody>
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<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL OD:</td>
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<td></td>
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<tr>
<td>0.660</td>
<td>0.860</td>
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</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa

* Table entries are rounded to 3 significant digits.
<table>
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<td>LENGTH (feet)</td>
<td>CAPACITY IN CUBIC FEET OF GAS PER HOUR</td>
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</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa, 1 inch water column = 0.249 kPa

Notes:
1 CTS = Copper tube size.
2 Table entries are rounded to 3 significant digits.
3 NA means a flow of less than 10 ft³/h (0.283 m³/h).
### Table 1315.2(24)

#### Schedule 40 Metallic Pipe [NFPA 54: Table 6.3.1(a)]

<table>
<thead>
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<th>Nominal Inside:</th>
<th>Pipe Size (inch)</th>
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<th>1⁄4</th>
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<th>2 1⁄4</th>
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<th>4</th>
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<tbody>
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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

*Table entries are rounded to 3 significant digits.*
TABLE 1315.2(25)
SCHEDULE 40 METALLIC PIPE (NFPA 54: TABLE 6.3.1(b))

| INTENDED USE: PIPE SIZING BETWEEN FIRST STAGE (HIGH PRESSURE) REGULATOR AND SECOND STAGE (LOW PRESSURE) REGULATOR |
|---|---|---|---|---|---|---|---|---|
| PIPE SIZE (inch) | NOMINAL INSIDE: | 1⁄8 | 1⁄4 | 1⁄2 | 3⁄4 | 1 | 11⁄2 | 2 |
| LENGTH (feet) | ACTUAL | 0.622 | 0.824 | 1.049 | 1.380 | 1.610 | 2.067 | 2.469 | 3.068 | 4.026 |
| CAPACITY IN THOUSANDS OF BTU PER HOUR | | | | | | | | | |
| 10 | 5890 | 12 300 | 23 200 | 47 600 | 71 300 | 137 000 | 219 000 | 387 000 | 789 000 |
| 20 | 4050 | 8460 | 15 900 | 32 700 | 49 000 | 94 400 | 150 000 | 266 000 | 543 000 |
| 30 | 3250 | 6790 | 12 800 | 26 300 | 39 400 | 75 800 | 121 000 | 214 000 | 436 000 |
| 40 | 2780 | 5810 | 11 000 | 22 500 | 33 700 | 64 900 | 103 000 | 183 000 | 373 000 |
| 50 | 2460 | 5150 | 9710 | 19 900 | 29 900 | 57 500 | 91 600 | 162 000 | 330 000 |
| 60 | 2230 | 4670 | 8790 | 18 100 | 27 100 | 52 100 | 83 000 | 147 000 | 299 000 |
| 70 | 2050 | 4300 | 8090 | 16 600 | 24 900 | 47 900 | 76 400 | 135 000 | 275 000 |
| 80 | 1910 | 4000 | 7530 | 15 500 | 23 200 | 44 600 | 71 100 | 126 000 | 256 000 |
| 90 | 1790 | 3750 | 7060 | 14 500 | 21 700 | 41 800 | 66 700 | 118 000 | 240 000 |
| 100 | 1690 | 3540 | 6670 | 13 700 | 20 500 | 39 500 | 63 000 | 111 000 | 227 000 |

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa
* Table entries are rounded to 3 significant digits.
### TABLE 1315.2(26)
**SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.3.1(c)]**

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<th>1⁄4</th>
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<th>1⁄2</th>
<th>3⁄4</th>
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<td>1.049</td>
<td>1.380</td>
<td>1.610</td>
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<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
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</table>

**PIPE SIZE (inch)**

| ACTUAL ID: | 0.622 | 0.824 | 1.049 | 1.380 | 1.610 | 2.067 | 2.469 | 3.068 | 4.026 |

**CAPACITY IN THOUSANDS OF BTU PER HOUR**

<table>
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<th>PRESSURE DROP: 1.0 psi</th>
<th>SPECIFIC GRAVITY: 1.50</th>
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</table>

**INTENDED USE:** PIPE SIZING BETWEEN 2 PSI SERVICE AND LINE PRESSURE REGULATOR

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

* Table entries are rounded to 3 significant digits.
### TABLE 1315.2(27)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.3.1(d)]

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<th>⅛</th>
<th>⅜</th>
<th>⅜</th>
<th>⅝</th>
<th>⅝</th>
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<table>
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<th>LENGTH (feet)</th>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
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For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 inch water column = 0.249 kPa

* Table entries are rounded to 3 significant digits.
**TABLE 13.15.2(28)**

**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.3.1(e)]**

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<td></td>
<td>1.481</td>
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<tr>
<td></td>
<td>1.959</td>
</tr>
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</table>

**CAPACITY IN THOUSANDS OF BTU PER HOUR**

<table>
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<th>20</th>
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<td>13500</td>
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<td>12400</td>
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<td>10400</td>
<td>9700</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

**Notes:**

1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Table entries are rounded to 3 significant digits.
### TABLE 1315.2(29)
**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.3.1(0)]**

<table>
<thead>
<tr>
<th>INTENDED USE: TUBE SIZING BETWEEN SINGLE OR SECOND STAGE (LOW PRESSURE) REGULATOR AND APPLIANCE</th>
<th>GAS: UNDILUTED PROPANE</th>
</tr>
</thead>
<tbody>
<tr>
<td>K &amp; L:</td>
<td>INLET PRESSURE: 11.0 in. w.c.</td>
</tr>
<tr>
<td>ACR:</td>
<td>PRESSURE DROP: 0.5 in. w.c.</td>
</tr>
<tr>
<td>SPECIFIC GRAVITY: 1.50</td>
<td></td>
</tr>
</tbody>
</table>

#### TUBE SIZE (inch)

<table>
<thead>
<tr>
<th>NOMINAL:</th>
<th>⅛</th>
<th>⅛</th>
<th>⅝</th>
<th>⅝</th>
<th>⅝</th>
<th>½</th>
<th>½</th>
<th>½</th>
<th>⅛</th>
<th>⅛</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTSIDE:</td>
<td>0.375</td>
<td>0.500</td>
<td>0.625</td>
<td>0.750</td>
<td>0.875</td>
<td>1.125</td>
<td>1.375</td>
<td>1.625</td>
<td>2.125</td>
<td></td>
</tr>
<tr>
<td>INSIDE:</td>
<td>0.305</td>
<td>0.402</td>
<td>0.527</td>
<td>0.652</td>
<td>0.745</td>
<td>0.995</td>
<td>1.245</td>
<td>1.481</td>
<td>1.959</td>
<td></td>
</tr>
</tbody>
</table>

#### CAPACITY IN THOUSANDS OF BTU PER HOUR

<table>
<thead>
<tr>
<th>LENGTH (feet)</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125</td>
<td>150</td>
<td>175</td>
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<td>1500</td>
<td>1600</td>
<td>1700</td>
<td>1800</td>
<td>1900</td>
<td>2000</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 inch water column = 0.249 kPa

**Notes:**

1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Table entries are rounded to 3 significant digits.
3. NA means a flow of less than 10,000 Btu/h (2.93 kW).
### Table 1315.2(30)

**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.3.1(g)]**

<table>
<thead>
<tr>
<th>OUTSIDE:</th>
<th>0.375</th>
<th>0.500</th>
<th>0.625</th>
<th>0.750</th>
<th>0.875</th>
<th>1.000</th>
<th>1.250</th>
<th>1.375</th>
<th>1.625</th>
<th>2.125</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSIDE:</td>
<td>0.305</td>
<td>0.402</td>
<td>0.527</td>
<td>0.652</td>
<td>0.745</td>
<td>0.995</td>
<td>1.245</td>
<td>1.481</td>
<td>1.959</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Table capacities are based on Type K copper tubing inside diameter (shown), which has the smallest inside diameter of the copper tubing products.
2. Table entries are rounded to 3 significant digits.

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

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### TABLE 1315.2(31)
**CORRUGATED STAINLESS STEEL TUBING (CSST)** [NFPA 54: TABLE 6.3.1(h)]\(^1,2\)

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 inch water column = 0.249 kPa

**Notes:**
1. Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: 
\[
L = 1.3n,
\]
where \(L\) is additional length (ft) of tubing and \(n\) is the number of additional fittings, bends, or both.
2. Table entries are rounded to 3 significant digits.
3. EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

<table>
<thead>
<tr>
<th>LENGTH (feet)</th>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
</tr>
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<tbody>
<tr>
<td>5</td>
<td>72</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
</tr>
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<td>15</td>
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</tr>
<tr>
<td>250</td>
<td>8</td>
</tr>
<tr>
<td>300</td>
<td>8</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 inch water column = 0.249 kPa
### TABLE 1315.2(32)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.3.1(i)]1, 2, 3, 4

**GAS:** UNDILUTED PROPANE

**INLET PRESSURE:** 2.0 psi

**PRESSURE DROP:** 1.0 psi

**SPECIFIC GRAVITY:** 1.50

**INTENDED USE:** CSST SIZING BETWEEN 2 PSI SERVICE AND LINE PRESSURE REGULATOR

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</thead>
<tbody>
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<td>LENGTH (feet)</td>
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<td></td>
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<td></td>
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<td></td>
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</table>

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

**Notes:**

1 Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 0.5 psi (3.4 kPa) [based on 13 inch water column (3.2 kPa) outlet pressure], DO NOT use THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator are capable of varying with flow rate.

2 CAUTION: Capacities shown in table are capable of exceeding the maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.

3 Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$, where $L$ is additional length (ft) of tubing and $n$ is the number of additional fittings, bends, or both.

4 Table entries are rounded to 3 significant digits.

5 EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
## TABLE 1315.2(33)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.3.1(j)]\(^1, 2, 3, 4\)

**GAS:** UNDILUTED PROPANE

**INLET PRESSURE:** 5.0 psi

**PRESSURE DROP:** 3.5 psi

**SPECIFIC GRAVITY:** 1.50

<table>
<thead>
<tr>
<th>FLOW DESIGNATION</th>
<th>13</th>
<th>15</th>
<th>18</th>
<th>19</th>
<th>23</th>
<th>25</th>
<th>30</th>
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<th>37</th>
<th>39</th>
<th>46</th>
<th>48</th>
<th>60</th>
<th>62</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH (feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>14 441</td>
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<td>8400</td>
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<td>40 400</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

**Notes:**

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 0.5 psi (3.4 kPa) [based on 13 inch water column (3.2 kPa) outlet pressure], DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator are capable of varying with flow rate.

2. CAUTION: Capacities shown in table are capable of exceeding the maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.

3. Table includes losses for four 90 degree (1.57 rad) bends and two end fittings. Tubing runs with larger numbers of bends, fittings, or both shall be increased by an equivalent length of tubing to the following equation: \( L = 1.3n \), where \( L \) is additional length (ft) of tubing and \( n \) is the number of additional fittings, bends, or both.

4. Table entries are rounded to 3 significant digits.

5. EHD = Equivalent Hydraulic Diameter, which is a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
TABLE 1315.2(34)
POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.3.1(k)]

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>DESIGNATION: SDR 9.3</th>
<th>SDR 11</th>
<th>SDR 11</th>
<th>SDR 10</th>
<th>SDR 11</th>
<th>SDR 11</th>
<th>SDR 11</th>
<th>SDR 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTUAL ID:</td>
<td>0.660</td>
<td>0.860</td>
<td>1.077</td>
<td>1.328</td>
<td>1.554</td>
<td>1.943</td>
<td>2.864</td>
<td>3.682</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LENGTH (feet)</th>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>340</td>
</tr>
<tr>
<td>20</td>
<td>233</td>
</tr>
<tr>
<td>30</td>
<td>187</td>
</tr>
<tr>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>50</td>
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<td>70</td>
<td>119</td>
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</tr>
<tr>
<td>450</td>
<td>43</td>
</tr>
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<td>500</td>
<td>41</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 inch water column = 0.249 kPa
* Table entries are rounded to 3 significant digits.
TABLE 1315.2(35)
POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.3.1(l)]*

<table>
<thead>
<tr>
<th>Nominal OD:</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1 1/4</th>
<th>1 1/2</th>
<th>1 3/4</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>Designation:</td>
<td>SDR 9.3</td>
<td>SDR 11</td>
<td>SDR 10</td>
<td>SDR 11</td>
<td>SDR 11</td>
<td>SDR 11</td>
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</tr>
<tr>
<td>Actual ID:</td>
<td>0.660</td>
<td>0.860</td>
<td>1.077</td>
<td>1.328</td>
<td>1.554</td>
<td>1.943</td>
<td>2.864</td>
<td>3.682</td>
<td>5.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length (feet)</th>
<th>Capacity in thousands of BTU per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3130 6260 11 300 19 600 29 500 53 100 147 000 284 000</td>
</tr>
<tr>
<td>20</td>
<td>2150 4300 7760 13 400 20 300 36 500 101 000 195 000</td>
</tr>
<tr>
<td>30</td>
<td>1730 3450 6230 10 800 16 300 29 300 81 100 157 000</td>
</tr>
<tr>
<td>40</td>
<td>1480 2960 5330 9240 14 000 25 100 69 400 134 100</td>
</tr>
<tr>
<td>50</td>
<td>1310 2620 4730 8190 12 400 22 200 61 500 119 000</td>
</tr>
<tr>
<td>60</td>
<td>1190 2370 4280 7420 11 200 20 100 55 700 108 000</td>
</tr>
<tr>
<td>70</td>
<td>1090 2180 3940 6830 10 300 18 500 51 300 99 100</td>
</tr>
<tr>
<td>80</td>
<td>1010 2030 3670 6350 9590 17 200 47 700 92 200</td>
</tr>
<tr>
<td>90</td>
<td>952 1910 3440 5960 9000 16 200 44 700 86 500</td>
</tr>
<tr>
<td>100</td>
<td>899 1800 3250 5630 8500 15 300 42 300 81 700</td>
</tr>
<tr>
<td>125</td>
<td>797 1600 2880 4990 7530 13 500 37 500 72 400</td>
</tr>
<tr>
<td>150</td>
<td>722 1450 2610 4520 6830 12 300 33 900 65 600</td>
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<tr>
<td>175</td>
<td>664 1330 2400 4160 6280 11 300 31 200 60 300</td>
</tr>
<tr>
<td>200</td>
<td>618 1240 2230 3870 5840 10 500 29 000 56 100</td>
</tr>
<tr>
<td>250</td>
<td>548 1100 1980 3430 5180 8500 15 300 42 300 81 700</td>
</tr>
<tr>
<td>300</td>
<td>496 994 1790 3110 4690 8430 23 300 45 100</td>
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<tr>
<td>350</td>
<td>457 914 1650 2860 4320 7760 21 500 41 500</td>
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<td>425 851 1530 2660 4020 7220 12 000 38 600</td>
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<td>399 798 1440 2500 3770 6770 18 700 36 200</td>
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<td>500</td>
<td>377 754 1360 2360 3560 6390 17 700 34 200</td>
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<td>358 716 1290 2240 3380 6070 16 800 32 500</td>
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<td>600</td>
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<tr>
<td>650</td>
<td>327 654 1180 2040 3090 5550 15 400 29 700</td>
</tr>
<tr>
<td>700</td>
<td>314 628 1130 1960 2970 5330 14 700 28 500</td>
</tr>
<tr>
<td>750</td>
<td>302 605 1090 1890 2860 5140 14 200 27 500</td>
</tr>
<tr>
<td>800</td>
<td>292 585 1050 1830 2760 4960 13 700 26 500</td>
</tr>
<tr>
<td>850</td>
<td>283 566 1020 1770 2670 4800 13 300 25 700</td>
</tr>
<tr>
<td>900</td>
<td>274 549 990 1710 2590 4650 12 900 24 900</td>
</tr>
<tr>
<td>950</td>
<td>266 533 961 1670 2520 4520 12 500 24 200</td>
</tr>
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<td>1000</td>
<td>259 518 935 1620 2450 4400 12 200 23 500</td>
</tr>
<tr>
<td>1100</td>
<td>246 492 888 1540 2320 4170 11 500 22 300</td>
</tr>
<tr>
<td>1200</td>
<td>234 470 847 1470 2220 3980 11 000 21 300</td>
</tr>
<tr>
<td>1300</td>
<td>225 450 811 1410 2120 3810 10 600 20 400</td>
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<tr>
<td>1400</td>
<td>216 432 779 1350 2040 3660 10 100 19 600</td>
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<td>208 416 751 1300 1960 3530 9760 18 900</td>
</tr>
<tr>
<td>1600</td>
<td>201 402 725 1260 1900 3410 9430 18 200</td>
</tr>
<tr>
<td>1700</td>
<td>194 389 702 1220 1840 3300 9130 17 600</td>
</tr>
<tr>
<td>1800</td>
<td>188 377 680 1180 1780 3200 8850 17 100</td>
</tr>
<tr>
<td>1900</td>
<td>183 366 661 1140 1730 3110 8590 16 600</td>
</tr>
<tr>
<td>2000</td>
<td>178 356 643 1110 1680 3020 8360 16 200</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 pound-force per square inch = 6.8947 kPa

* Table entries are rounded to 3 significant digits.
### TABLE 1315.2(36)

**POLYETHYLENE PLASTIC TUBING [NFPA 54: TABLE 6.3.1]**

<table>
<thead>
<tr>
<th>GAS: UNDILUTED PROPANE</th>
<th>INLET PRESSURE: 11.0 in. w.c.</th>
<th>PRESSURE DROP: 0.5 in. w.c.</th>
<th>SPECIFIC GRAVITY: 1.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTENDED USE: PE TUBE SIZING BETWEEN INTEGRAL SECOND-STAGE REGULATOR AT TANK OR SECOND-STAGE (LOW PRESSURE) REGULATOR AND BUILDING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLASTIC TUBING SIZE (CTS)</td>
<td>NOMINAL OD: ½</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DESIGNATION:</td>
<td>SDR 7</td>
<td>SDR 11</td>
<td></td>
</tr>
<tr>
<td>ACTUAL ID:</td>
<td>0.445</td>
<td>0.927</td>
<td></td>
</tr>
<tr>
<td>LENGTH (feet)</td>
<td>CAPACITY IN THOUSANDS OF BTU PER HOUR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>121</td>
<td>828</td>
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<tr>
<td>20</td>
<td>83</td>
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<tr>
<td>500</td>
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<td>100</td>
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</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW, 1 inch water column = 0.249 kPa

**Notes:**
1. CTS = Copper tube size.
2. Table entries are rounded to 3 significant digits.
CHAPTER 14
PROCESS PIPING

1401.0 General.
1401.1 Applicability. Except as otherwise addressed in this code, this chapter shall govern the installation of process piping in or in conjunction with a building or structure located upon the premises.

1402.0 Permit.
1402.1 General. It shall be unlawful to install, alter, or repair or cause to be installed, altered, or repaired process material piping without first obtaining a permit.

Permits for process piping shall show the total number of outlets to be provided for on each system and such other information as required by the Authority Having Jurisdiction.

Fees for process piping permits are included in Table 104.5.

1403.0 Plans Required.
1403.1 General. Plans, engineering calculations, diagrams, and other data shall be submitted in one or more sets with each application for a permit. The Authority Having Jurisdiction shall be permitted to require plans, computations, and specifications to be prepared and designed by a registered design professional.

Where plans or other data are submitted for review, a plan review fee shall be paid, as provided in Section 104.3.2.

1404.0 Workmanship.
1404.1 General. Process piping shall not be strained or bent, nor shall tanks, vessels, vats, appliances, or cabinets be supported by or develop strain or stress on the piping.

1405.0 Inspections.
1405.1 General. Upon completion of the installation, alteration, or repair of process piping, and prior to the use thereof, the Authority Having Jurisdiction shall be notified that such piping is ready for inspection.

Excavations required for the installation of underground piping shall be kept open until such time as the piping has been inspected and approved. Where such piping is covered or concealed before such approval, it shall be exposed upon the direction of the Authority Having Jurisdiction.

1405.2 Required Inspections. The Authority Having Jurisdiction shall make the following inspections and shall either approve that portion of the work as completed or shall notify the permit holder wherein the same fails to be in accordance with this code.

1405.2.1 Rough Piping Inspection. This inspection shall be made after process piping authorized by the permit has been installed and before piping has been covered or concealed. This inspection shall include a determination that the piping size, material, and installation are in accordance with the requirements of this code.

1405.2.2 Final Piping Inspection. This inspection shall be made after piping authorized by the permit has been installed and after portions thereof that are to be covered or concealed are so concealed. This inspection shall include a pressure test, at which time the piping shall stand a pressure of not less than one-and-one-half times the maximum designed operating pressure where hydraulic testing is conducted or 110 percent where testing is conducted pneumatically. Test pressures shall be held for a length of time satisfactory to the Authority Having Jurisdiction, but in no case for less than 30 minutes with no perceptible drop in pressure. HPM drain, waste, and vent piping shall be tested in accordance with the plumbing code. Tests shall be made in the presence of the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder.

1405.3 Other Inspections. In addition to the inspections required by this section, the Authority Having Jurisdiction shall be permitted to require a special inspector, as specified in the building code, during installation of piping systems. In cases where the work authorized was installed in accordance with plans and specifications prepared by a registered design professional, the Authority Having Jurisdiction shall be permitted to require a final signed report stating that the work was installed in accordance with approved plans and specifications and the applicable provisions of this chapter.

1406.0 Pipe, Tubing, and Fittings.
1406.1 General. Process pipe, tubing, and fittings shall comply with the applicable standards in Table 1701.1ASME B31.3 and shall be installed in accordance with the manufacturer’s installation instructions. Materials shall be rated for the operating temperatures and pressures of the system, and shall be compatible with the type of liquid.

1406.2 Hazardous Process Piping (HPP). HPP supply piping or tubing in service corridors shall be exposed to view. HPP piping shall be identified in accordance with nationally recognized standards to indicate the material being transported. Liquid HPP piping shall have an approved means for directing spilled materials to an approved containment or drainage system.

Liquid HPP waste or drainage systems shall be installed in accordance with the plumbing code.

1406.2.1 Installation in Exit Corridors and Above Other Occupancies. Hazardous process supply pipe shall not be located within exit corridors, within a portion of a means of egress required to be enclosed in fire-resistant construction, or in concealed spaces in or above
areas not classified as Group H Occupancies, except as permitted by this subsection.

Hazardous production material piping and tubing shall be permitted to be installed within the space defined by the walls of exit corridors and the floor or roof above, or in concealed spaces above other occupancies in accordance with Section 1406.2.1.1 through Section 1406.2.1.6.

1406.2.1.1 Automatic Sprinklers. Automatic sprinklers shall be installed within the space unless the space is less than 6 inches (152 mm) in the least dimension.

1406.2.1.2 Ventilation. Ventilation at not less than 6 air changes per hour (ACH) shall be provided. The space shall not be used to convey air from other areas.

1406.2.1.3 Receptor. Where the piping or tubing is used to transport HPP liquids, a receptor shall be installed below such piping or tubing. The receptor shall be designed to collect discharge or leakage and drain it to an approved location. The 1 hour enclosure shall not be used as part of the receptor.

1406.2.1.4 Separation. HPP supply piping and tubing and HPP nonmetallic waste lines shall be separated from the exit corridor and from an occupancy other than a semi-conductor fabrication facility classified as a Group H Occupancy by construction, as required for walls or partitions that have a fire-protection rating of not less than 1 hour. Where gypsum wallboard is used, joints on the piping side of the enclosure need not be taped, provided the joints occur over framing members. Access openings into the enclosure shall be protected by approved fire assemblies.

1406.2.1.5 Emergency Shutoff Valves. Readily accessible manual or automatic remotely activated fail-safe emergency shutoff valves shall be installed on piping and tubing other than waste lines at the following locations:

(1) At branch connections into the fabrication area.
(2) At entries into exit corridors. Excess flow valves shall be installed as required by the fire code.

1406.2.1.6 Electrical Wiring. Electrical wiring and equipment located in the piping space shall be approved for Class I, Division 2, Hazardous Locations.

Exception: Occasional transverse crossing of the corridors by supply piping that is enclosed within the corridor need not comply with Section 1406.2.1.1 through Section 1406.2.1.6.

1406.3 Special Requirements for HPP Gases. In addition to other requirements of this section, HPP gases shall comply with this subsection and the fire code.

1406.3.1 Special Provisions. Where HPP supply gas is carried in pressurized piping, a fail-safe system shall shut off flow due to a rupture in the piping. Where the piping originates from outside the building, the valve shall be located outside the building as close to the bulk source as practical.

1406.3.2 Piping and Tubing Installation. Piping and tubing shall be installed in accordance with approved standards. Supply piping for hazardous production materials having a health hazard ranking of 3 or 4 shall have welded connections throughout, unless an exhausted enclosure is provided.

Exception: Material that is incompatible with ferrous piping shall be permitted to be installed in nonmetallic piping with approved connections.

1406.3.3 Gas-Detection System. Where hazardous production material gas is used or dispensed and the physiological warning properties of the gas are at a higher level than the accepted permissible exposure limit for the gas, a continuous gas-monitoring system shall be provided to detect the presence of the short-term hazard condition. Where dispensing occurs and flammable gases or vapors are capable of being present in quantities in excess of 25 percent of the lower explosive limit, a continuous gas-monitoring system shall be provided. The monitoring system shall be connected to the emergency control station.
CHAPTER 15
SOLAR ENERGY SYSTEMS

1501.0 General.
1501.1 Applicability. See Section 1203.0 and the Uniform Solar Energy and Hydronics Code (USEHC) Uniform Solar, Hydronics and Geothermal Code (USHGC), published by the International Association of Plumbing and Mechanical Offi-
cials. The Uniform Solar Energy and Hydronics Code (USEHC) Uniform Solar, Hydronics and Geothermal Code (USHGC) provides requirements that shall be permitted to be adopted as part of the code by the Authority Having Jurisdi-
tion.
CHAPTER 16
STATIONARY POWER PLANTS

1601.0 Stationary Fuel Cell Power Plants.
1601.1 General. Fuel cell power plants with a power output of less than 50 kW shall be listed and installed in accordance with the manufacturer’s instructions. Fuel cell power plants with a power output of greater than 50 kW shall be installed in accordance with NFPA 853. [NFPA 54:10.30] Stationary fuel cell power plants shall be tested in accordance with CSA FC-1.

1602.0 Stationary Gas Engines and Generators.
1602.1 General. The installation of gas engines shall conform to NFPA 37. [NFPA 54:10.23]
1602.2 Connection to the Gas Supply Piping. Stationary gas engines shall not be rigidly connected to the gas supply piping. [NFPA 54:10.23.1]
1602.3 Stationary Engine Generators. Stationary engine generators shall be tested in accordance with UL 2200, and shall be installed in accordance with NFPA 37 and the manufacturer’s installation instructions.
Chapter 17
Referenced Standards

1701.0 General.
1701.1 Standards. The standards listed in Table 1701.1 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 acronym referred to in Table 1701.1 are defined in a list found at the end of the table.

<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>AABC-2016</td>
<td>Total System Balance, 7th Edition</td>
<td>Balancing</td>
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<td>ACCA Manual B-2009</td>
<td>Balancing and Testing Air and Hydronic Systems</td>
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<td>Ducts, Balancing</td>
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<td>Residential Load Calculations</td>
<td>Ducts</td>
<td>1105.1</td>
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<td>Residential Equipment Selection</td>
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<td>ACCA 4 QM-2013</td>
<td>Maintenance of Residential HVAC Systems</td>
<td>HVAC Systems</td>
<td>102.3.2</td>
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<td>AHRI 700 2017a</td>
<td>Specifications for Refrigerants</td>
<td>Refrigerants</td>
<td>1104.7, 1104.7.3</td>
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<td>AMCA 540-2013</td>
<td>Louvers Impacted by Wind Borne Debris</td>
<td>Louvers</td>
<td>315.1.2</td>
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<tr>
<td>AMCA 550-2015</td>
<td>Test Method for High Velocity Wind Driven Rain Resistance Louvers</td>
<td>Louvers</td>
<td>315.1.1</td>
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<tr>
<td>ASHRAE 15-2016</td>
<td>Safety Standard for Refrigeration Systems</td>
<td>Refrigeration Systems</td>
<td>1102.1, 1106.1, Table 1113.5</td>
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<tr>
<td>ASHRAE 34-2016</td>
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The standards, publications, practices and guides listed in Table 1701.2 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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<tr>
<td>ACRA</td>
<td>Air Conditioning Contractors of America Association, Inc., 2800 S Shirlington Road, Suite 300, Arlington, VA 22206.</td>
</tr>
<tr>
<td>AMCA</td>
<td>Air Movement and Control Association, 30 West University Drive, Arlington Heights, IL 60004-1806.</td>
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<tr>
<td>ANSI</td>
<td>American National Standards Institute, Inc., 25 W. 43rd Street, 4th Floor, New York, NY 10036.</td>
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<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineering, Two Park Avenue, New York, NY 10016-5990.</td>
</tr>
<tr>
<td>ASSE</td>
<td>Air Movement and Control Association, 30 West University Drive, Arlington Heights, IL 60004-1806.</td>
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<td>ANSI</td>
<td>American National Standards Institute, Inc., 25 W. 43rd Street, 4th Floor, New York, NY 10036.</td>
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<td>ASME</td>
<td>American Society of Mechanical Engineering, Two Park Avenue, New York, NY 10016-5990.</td>
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<tr>
<td>ASSE</td>
<td>American Society of Sanitary Engineering, 18927 Hickory Creek Drive, Suite 220, Mokena, IL 60448.</td>
</tr>
<tr>
<td>ASTM</td>
<td>ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.</td>
</tr>
<tr>
<td>AWS</td>
<td>American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672.</td>
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<tr>
<td>AWWA</td>
<td>American Water Works Association, 6666 W. Quincy Avenue, Denver, CO 80235.</td>
</tr>
<tr>
<td>CGA</td>
<td>Canadian Gas Association, 243 Consumers Road, Suite 1200, North York, Ontario, Canada M2J 5E3.</td>
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<tr>
<td>CSA</td>
<td>Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3.</td>
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<td>e1</td>
<td>An editorial change since the last revision or reapproval.</td>
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<tr>
<td>IAPMO</td>
<td>International Association of Plumbing and Mechanical Officials, 4755 E. Philadelphia Street, Ontario, CA 91761.</td>
</tr>
<tr>
<td>IIAR</td>
<td>International Institute of Ammonia Refrigeration, 1001 N. Fairfax Street, Suite 503, Alexandria, VA 22314.</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization, 1 ch. de la Voie-Creuse, Casa Postale 56, CH-1211 Geneva 20, Switzerland.</td>
</tr>
<tr>
<td>MSS</td>
<td>Manufacturers Standardization Society of the Valve and Fittings Industry, 127 Park Street NE, Vienna, VA 22180.</td>
</tr>
<tr>
<td>NEBB</td>
<td>NEBB, 8575 Grovemont Circle, Gaithersburg, MD 20877.</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.</td>
</tr>
<tr>
<td>NSF</td>
<td>NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.</td>
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<tr>
<td>SMACNA</td>
<td>Sheet Metal and Air Conditioning Contractors National Association, 4201 Lafayette Center Drive, Chantilly, VA 20151-1219.</td>
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<td>UL</td>
<td>Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062.</td>
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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
RESIDENTIAL PLANS EXAMINER REVIEW FORM FOR HVAC SYSTEM DESIGN
(Loads, Equipment, Ducts) [ACCA]

The following Residential Plans Examiner Review Form for HVAC System Design (Loads, Equipment, Ducts), Form RPER1, is included here for the convenience of the users of the Uniform Mechanical Code.

![Residential Plans Examiner Review Form for HVAC System Design (Loads, Equipment, Ducts)](image)

### HVAC LOAD CALCULATION (See Section 1105.1)

**Design Conditions**
- **Winter Design Conditions**
  - Outdoor temperature: °F
  - Indoor temperature: °F
  - Total heat loss: Btu
- **Summer Design Conditions**
  - Outdoor temperature: °F
  - Indoor temperature: °F
  - Grains difference: \( \Delta G_f \) % Rh
  - Sensible heat gain: Btu
  - Latent heat gain: Btu
  - Total heat gain: Btu

### HVAC EQUIPMENT SELECTION

#### Heating Equipment Data
- Equipment type (e.g., Furnace, Heat pump, Boiler, etc.)
- Model
- Heating output capacity: Btu
- Auxiliary heat output capacity: Btu

#### Cooling Equipment Data
- Equipment type (e.g., Air Conditioner, Heat pump, etc.)
- Model
- Sensible cooling capacity: Btu
- Latent cooling capacity: Btu

#### Blower Data
- Heating CFM: CFM
- Cooling CFM: CFM
- Static pressure: IWC

### HVAC DUCT DISTRIBUTION SYSTEM DESIGN (See Section 601.2)

- Design airflow: CFM
- External Static Pressure (ESP): IWC
- Component Pressure Losses (CPL): IWC
- Available Static Pressure (ASP): IWC

- Longest supply duct: Ft
- Longest return duct: Ft
- Total Effective Length (TEL): Ft
- Friction Rate: IWC

I declare the load calculation, equipment selection, and duct system design were rigorously performed based on the building plan listed above. I understand the claims made on these forms will be subject to review and verification.

Contractor's Printed Name: __________________________
Date: ____________

Contractor's Signature: __________________________

Reserved for County, Town, Municipality, or Authority having jurisdiction use.

* Home qualifies for MRAE Form based on Abridged Edition Checklist.
APPENDIX B
PROCEDURES TO BE FOLLOWED TO PLACE GAS EQUIPMENT IN OPERATION

B 101.0 Adjusting the Burner Input.
B 101.1 Adjusting Input. The input rate of the burner shall be adjusted to the value in accordance with the appliance manufacturer’s instructions. Firing at a rate in excess of the nameplate rating shall be prohibited. The input rate can be adjusted by changing the size of a fixed orifice, changing the adjustment of an adjustable orifice, or readjusting the appliance’s gas pressure regulator outlet pressure (where a regulator is provided in the appliance). [NFPA 54:11.1.1, 11.1.1.1]

B 101.2 High Altitude. Gas input ratings of appliances shall be used for elevations up to 2000 feet (610 m). The input rating of appliances operating at elevations above 2000 feet (610 m), shall be reduced in accordance with one of the following methods:
(1) At the rate of 4 percent for each 1000 feet (305 m) above sea level before selecting appropriately sized appliances.
(2) As permitted by the Authority Having Jurisdiction.
(3) In accordance with the manufacturer’s installation instructions. [NFPA 54:11.1.2]

B 102.0 Primary Air Adjustment.
B 102.1 General. The primary air for injection (Bunsen)-type burners shall be adjusted for flame characteristics in accordance with the appliance manufacturer’s instructions. After setting the primary air, the adjustment means shall be secured in position. [NFPA 54:11.1.2]

B 103.0 Safety Shutoff Devices.
B 103.1 General. Where a safety shutoff device is provided, it shall be checked for operation and adjustment in accordance with the appliance manufacturer’s instructions. Where the device does not function properly to turn off the gas supply in the event of pilot outage or other improper operation, it shall be serviced or replaced with a new device. [NFPA 54:11.3]

B 104.0 Automatic Ignition.
B 104.1 General. Appliances supplied with means for automatic ignition shall be checked for operation within the parameters provided by the manufacturer. Any adjustments made shall be in accordance with the manufacturer’s installation instructions. [NFPA 54:11.4]

B 105.0 Protective Devices.
B 105.1 General. Where required by the manufacturer’s installation instructions, all protective devices furnished with the appliance such as a limit control, fan control to blower, temperature- and pressure-relief valve, low-water cutoff device, or manual operating features, shall be checked for operation within the parameters provided by the manufacturer. Any adjustments made shall be in accordance with the manufacturer’s installation instructions. [NFPA 54:11.5]

B 106.0 Checking the Draft.
B 106.1 General. Draft hood-equipped appliances shall be checked to verify that there is no draft hood spillage after 5 minutes of main burner operation. [NFPA 54:11.6]

B 107.0 Operating Instructions.
B 107.1 General. Operating instructions shall be furnished and shall be left in a prominent position near the appliance for the use of the consumer. [NFPA 54:11.7]
APPENDIX C
INSTALLATION AND TESTING OF OIL (LIQUID) FUEL-FIRED EQUIPMENT

C 101.0 General.

C 101.1 Applicability. Appendix C governs the installation, testing, or repair of oil or liquid fuel burners, oil or liquid fuel-burning systems, oil or liquid fuel-burning equipment, and the oil or liquid fuel piping systems used in connection with buildings or structures and equipment within the property lines of the premises.

C 102.0 Definitions.

Anti-Flooding Device. A primary safety control that causes the flow of oil or fuel to be shut off after a rise in oil or fuel level, or after receiving excess oil or fuel, and that operates before the hazardous discharge of oil or fuel can occur.

Burner, Automatically Ignited. A burner equipped so that main burner fuel may be turned on and ignited automatically.

Burner, Manually Ignited. A burner equipped, so that main burner fuel is turned on only by hand and ignited under supervision.

Burner, Mechanical Draft Type. A burner that includes a power-driven fan, blower, or other mechanism as the primary means for supplying the air for combustion.

Burner, Natural Draft Type. A burner that depends primarily on the natural draft created in the chimney or venting system to induce air required for combustion into the burner.

Constant Level Valve. A device for maintaining within a reservoir a constant level of oil or fuel for delivery to a burner.

Control Limit. An automatic safety control that is responsive to changes in fluid flow or level, pressure, or temperature and that is normally set beyond the operating range for limiting the operation of the controlled equipment by shutting off the energy supply.

Control Safety. Automatic interlock controls, including relays, switches, and other auxiliary equipment used in conjunction with them, to form a safety control system that is intended to prevent unsafe operation of the controlled equipment.

Draft Booster. A power-operated fan, blower, or other device installed in the chimney connector to increase the natural draft developed in the connected chimney.

Draft Regulator, Barometric. A device built into a fuel-burning appliance or made part of a chimney connector or vent connector that functions to reduce excessive draft through an appliance to a desired value by admitting ambient air into the appliance chimney, chimney connector, vent, or vent connector.

Fuel. Natural, manufactured, or liquefied petroleum gas, or a mixture of these gases; all grades of fuel oil, wood, or any other combustible or flammable material or any mixture of combustible or flammable materials.

Fuel Burner. A device used to convey the appropriate fuel into the combustion chamber zone in close proximity to its primary and secondary air supply to permit a stable controlled heat release compatible with the burner design, listing, and applicable approvals in a boiler, furnace, device or appliance. It includes but is not limited to burning oil or liquid fuel.

Fuel Burner System. The fuel burner and a conveyance system or piping system for the purpose of introducing the appropriate fuel into the combustion chamber zone.

Fuel-Burning Equipment/Appliance. An oil or fuel burner of any type including all oil or liquid fuel burners, oil or liquid fuel-fired units, dual, or multi-fuel burners and heating and cooking appliances with their fuel burner system and with their tank or fuel storage system, piping system, vent connectors, vent flues, fans, blowers, valves, control devices, combustion air, wiring, controls, and related devices including all accessories and appurtenances for safe and proper operation of the appliance.

Fuel Oil. Hydrocarbon oil as specified by ASTM D396, or the Canadian Government Specification Board, 3-GP-28, and having a flashpoint of not less than 100°F (38°C).

Fuel-Piping System. Method of conveying liquid, vapor, steam, gases, or slurry from one point to another, including accessories, appurtenances, and equipment necessary for its proper operation.

Indirect-Fired Appliance. An oil or fuel-burning appliance in which products of combustion (flue gases) are not mixed in the appliance with the air or other medium being heated.

Labeled. Having attached a label, symbol, or other identifying mark of an organization acceptable to the Authority Having Jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Premixing. A power burner in which all or nearly all of the air for combustion is mixed with the gas as primary air.

Pump, Oil or Fuel Transfer. An oil or fuel pump, automatically or manually operated, that transfers oil or fuel through continuous piping from a supply tank to an oil or fuel-burning appliance or to an auxiliary tank, and that is not designed to stop pumping automatically in case of total breakage of the oil or fuel supply line between the pump and the appliance.

Tank, Auxiliary. A tank having a capacity of not over 60 gallons (227 L) listed for installation in the supply piping between a burner and its main fuel supply tank. It shall be permitted to be included as an integral part of an automatic pump or a transfer pump, or it shall be permitted to be a separate tank.
APPENDIX C

Tank, Gravity. A supply tank from which the oil or fuel is delivered directly to the burner by gravity.

Tank, Integral. A tank that is furnished by the manufacturer as an integral part of an oil or fuel-burning appliance.

Tank Storage. A separate tank that is not connected to the oil or fuel-burning appliance.

Tank Supply. A separate tank connected directly or by a pump to the oil or fuel-burning appliance.

Tank, Vacuum or Barometric. A tank not exceeding 5 gallons (19 L) capacity that maintains a definite level of oil or fuel in a sump or similar receptacle by barometric feed. Fuel is delivered from the sump to the burner by gravity.

Valve, Manual Oil, Gas, or Fuel Shutoff. A manually operated valve in a fuel line for the purpose of turning on or completely shutting off the fuel supply to the burner.

Valve, Oil, Gas, or Fuel Control. An automatically or manually operated device consisting essentially of a fuel valve for controlling the fuel supply to a burner.

C 103.0 Standards and Accepted Practices.

C 103.1 General. The installation, testing, and repair of oil or liquid fuel-burning equipment systems shall be in accordance with Section C 103.0, the standards listed in Chapter 17, and other information outlined in this code such as, but not limited to, combustion air, flue and breeching requirements, room clearances and dimensions, and control requirements.

C 104.0 Approval of Equipment.

C 104.1 General. Oil or liquid fuel-burning equipment shall be approved.

C 105.0 Placing Equipment in Operation.

C 105.1 General. After completion of installations, the installer shall test safety and operating controls and venting before placing the burner in service. The correct input of liquid fuel shall be determined, and the fuel-to-air ratio shall be set. Each oil or liquid fuel burner shall be adjusted to its input according to the manufacturer’s instructions. Overrating the burners or the appliance is prohibited. The input range shall be appropriate to the appliance:

1. For conversion burners installed in hot water (liquid) boilers or warm air furnaces, the rate of flow of the oil or liquid fuel in British thermal units per hour (Btu/h) (kW) shall be adjusted to within plus or minus 5 percent of the design load, not to exceed the design rate of the appliance.

2. For conversion burners installed in steam boilers, the oil or liquid fuel hourly input demand shall be adjusted to be in accordance with the steam load requirements. The oil or liquid fuel input demand necessitated by an oversized boiler shall be established and added to total input demand.

C 106.0 Pilot Operation.

C 106.1 General. Igniter or pilot flames shall be effective to ignite the oil or liquid fuel at the main burner or burners and shall be adequately protected from drafts. Pilot flames shall not become extinguished during the pilot cycle where the main burner or burners are turned on or off in a normal manner either manually or by automatic controls.

C 107.0 Burner Operation.

C 107.1 General. In making tests to determine compliance with the requirements of Section C 107.1, the following care shall be exercised to prevent the accumulation of unburned liquid fuel in the appliance that will result in an explosion or fire:

1. The flames from the burner shall ignite freely the liquid fuel where operating at the lowest firing position.

2. Burner flames shall not flash back where the liquid fuel is turned on or off by an automatic control mechanism.

3. Main burner flames shall ignite freely from the pilot where the pilot flame is reduced to a minimum point that will actuate the pilot safety device.

4. Where ignition is made in a normal manner, the flame will not flash outside the appliance.

5. Burners shall not expel liquid fuel through air openings where operating at prevailing pressure.

6. Burners shall have a liquid-fuel air mixture to ensure smooth ignition of the main burner.

C 108.0 Method of Test.

C 108.1 General Test Methods.

1. The flue gas, venting, safety and operating controls of the appliance shall be checked by the installer to ensure their proper and safe operation.

2. Method of test – atmospheric, induced draft or fan assisted types.

(a) The appliance shall be allowed to operate until the stack temperature becomes stabilized, after which a sample of the undiluted flue products shall be taken from the appliance flue outlet. The sample taken shall be analyzed for carbon monoxide, carbon dioxide, and oxygen. Stack temperature shall be noted.

   Appliance designs incorporating induced-draft assemblies require a flue gas sample to be taken ahead of the draft regulator or induced draft fan.

3. Performance standards for atmospheric type shall be provided in accordance with the following:

   (a) Shall be not less than 75 percent efficiency as determined by flue gas analysis method at the appliance flue outlet.

   (b) Carbon monoxide concentration in flue gas shall not exceed 0.04 percent.

   (c) Stack temperature shall not exceed 700°F (371°C) plus ambient.
(d) Carbon dioxide concentration shall be between 8 percent and 13 percent.
(e) Oxygen concentration shall be between 4 percent and 10 percent.
(f) Smoke test shall not exceed number 2 for light oils or number 4 for oils heavier than number 4.
(g) Draft shall comply with the burner manufacturer’s instructions.

(4) Performance standards for induced-draft or fan-assisted types shall comply with the following:
(a) Shall be not less than 75 percent efficiency, as determined by flue gas analysis method at appliance flue outlet.
(b) Carbon monoxide concentration in flue gas not exceeding 0.04 percent.
(c) Stack temperature shall not exceed 700°F (371°C) plus ambient.
(d) Carbon dioxide concentration shall be between 8 percent and 13 percent.
(e) Oxygen concentration shall be between 4 percent and 10 percent.
(f) Smoke test shall not exceed number 2 for light oils or number 4 for oils heavier than number 4.
(g) Draft shall comply with the burner manufacturer’s instructions.

Induced-draft and fan-assisted types of appliances require a sample be taken after the induced-draft fan that will cause oxygen figures in excess of the limits stated. In such cases, safe liquid fuel combustion ratios shall be maintained and be consistent with approvals and listings of the appliance.

(5) Method of test – power type.
(a) The appliance shall be allowed to operate until the stack temperature becomes stabilized; after that, a sample of the undiluted flue products shall be taken from the appliance flue outlet. The sample shall be analyzed for carbon monoxide, carbon dioxide, and oxygen. Stack temperature shall be noted.

(6) Performance standards for power type.
(a) Shall be not less than 80 percent efficiency as determined by flue gas analysis method at the appliance flue outlet.
(b) Carbon monoxide concentration in the flue gas shall not exceed 0.04 percent.
(c) Stack temperature shall not exceed 700°F (371°C) plus ambient.
(d) Carbon dioxide concentration shall be between 8 percent and 13 percent.
(e) Oxygen concentration shall be between 4 percent and 10 percent.
(f) Smoke test shall not exceed number 2 for light oils or number 4 for oils heavier than number 4.
(g) Draft shall comply with the burner manufacturer’s instructions.

(7) After completion of the test of newly installed oil or liquid fuel burner equipment as provided in this section, the installer shall file with the Authority Having Jurisdiction complete records of the test on a form approved by the Authority Having Jurisdiction. The tag stating the date of the test and the name of the installer shall be attached to the appliance at the main valve.

(8) Listing and approval.
(a) The concentration of oxygen in the undiluted flue products of oil or liquid fuel burners shall in no case be less than 3 percent nor exceed 10 percent and shall be in accordance with performance standards and shall be consistent with the listing and approval of the equipment.
(b) The allowable limit of carbon monoxide shall not exceed 0.04 percent.
(c) The flue gas temperature of an oil appliance, as taken on the appliance side of the draft regulator, shall not exceed applicable performance standards and shall be consistent with the listing and approvals of the equipment.

(9) The oxygen figures shall not apply where there is an approved oxygen trim system on the burner that is designed for that use, including a low oxygen interlock where approved by the Authority Having Jurisdiction.

(10) Supervision shall be as follows:
(a) Supervised startup shall be required to verify the safe operation of an oil or liquid fuel burner and to provide documentation that operation is consistent with this code, listing, and approval. Supervised startup shall be required for liquid fuel burners in Section C 109.1(2), Section C 109.1(3), and Section C 109.1(4). Supervised startup requires that the liquid-fuel burner shall be tested in the presence of the mechanical official in a manner set forth by the Authority Having Jurisdiction before the installation is approved. Testing shall include safety and operating controls, input, flue gas analysis, and venting. Flue gas shall be tested at high, medium, and low fires. Provisions shall be made in the system to allow a firing test in warm weather. After completion of the test of newly installed oil or liquid fuel burner equipment, as provided in this section, the installer shall file with the Authority Having Jurisdiction complete records of the test on a form approved by the Authority Having Jurisdiction. The tag stating the date of the test and the name of the tester shall be attached to the appliance at the main valve.
(b) Oil and liquid fuel burners of 1 000 000 Btu/h (293 kW) input or more require a supervised startup in accordance with Section C 108.1(10)(a).
(c) Installation of oxygen trim systems, modulating dampers, or other draft control or combustion devices require a supervised startup in accordance with Section C 108.1(10)(a).
(d) Direct-fired heaters shall require a supervised startup in accordance with Section C 108.1(10)(a).

(11) The complete control diagram of the installation and operating instructions shall be supplied and posted by the installer of the appliance.

C 109.0 Special Requirements Based on Btu/h Input.

C 109.1 General.

(1) Zero to 400 000 Btu/h (0 kW to 117 kW) per burner.
   (a) One approved manual shutoff valve lever handle.
   (b) One approved fuel oil filter, installed on the supply piping.
   (c) Approved automatic safety shutoff valve to provide 100 percent shutoff of all oil.
   (d) A flame safeguard control capable of providing 100 percent shutoff in the event of flame failure. Flame failure response timing shall not exceed the control manufacturer’s instructions.
   (e) Two controls, one operating and one high limit, activated by temperature or pressure, as appropriate.
   (f) Burners relying on mechanical means to provide air for combustion shall have actual proof-of-air interlock device.
   (g) Installations with dampered combustion air openings shall prove damper open position before trial for burner ignition.
   (h) Vent dampers and flue dampers shall be properly interlocked to prevent burner ignition unless safely open.

(2) Four hundred thousand and one to 999 999 Btu/h (117.2 kW to 292.9 kW) per burner.
   (a) One approved manual shutoff valve lever handle.
   (b) One approved fuel-oil filter, installed on the supply piping.
   (c) Two safety shutoff valves in series, maximum five seconds closing time.
   (d) One electronic flame safeguard pilot control providing a separately supervised and proven pilot, 100 percent shutoff manual reset. Flame failure response time shall not exceed the control manufacturer’s instructions.
   (e) Two controls, one operating and one high limit, activated by temperature or pressure, as appropriate.
   (f) Burners relying on mechanical means to provide air for combustion shall have actual proof-of-air interlock device.
   (g) Power burners shall include proven prepurge of not less than 60 seconds at high-fire damper settings. This prepurge shall occur before every burner cycle, regardless of reason.
   (h) Installations with dampered combustion air openings shall prove damper open position before trial for burner ignition.
   (i) Vent dampers and flue dampers shall be interlocked to prevent burner ignition unless safely open.
   (j) One high oil or liquid fuel-pressure interlock, reset from flame safeguard or manually.
   (k) Where hot water or steam, one low water cutoff.
   (l) An atomizing medium proving switch.
   (m) A low oil temperature switch for oil or liquid fuel requiring preheating.
   (n) A high oil temperature interlock for oil or liquid fuel requiring preheating.
   (o) The burner oil pump shall automatically not operate or rotate while the alternate fuel is firing.
   (p) A pressure-relief valve shall be provided between safety shutoff valves and between pump and safety valves where an integral valve is used with a pump.
   (q) A separate relief device is required on each transfer pump.

(3) One million to 2 499 999 Btu/h (293 kW to 732 kW) input per burner.
   (a) One approved manual shutoff valve lever handle.
   (b) One approved fuel-oil filter, installed on the supply piping.
   (c) Two safety shutoff valves in series with a combined flame failure response and valve closing time not to exceed 5 seconds with strainer directly before the valves.
   (d) Programmed electronic flame safeguard including proven low-fire start, manual reset lockout, 100 percent shutoff (both pilot and main burner), and a separately supervised and proven pilot.
      Flame-sensing systems utilizing a UV scanner shall prove pilot and interrupt ignition spark prior to main burner valves being energized.
   (e) Two controls, one operating and one high limit, activated by temperature or pressure.
   (f) Burners relying on mechanical means to provide air for combustion shall have actual proof-of-air interlock device.
   (g) Power burners shall include proven prepurge of not less than 60 seconds at high-fire damper settings. This prepurge shall occur before every burner cycle, regardless of reason.
   (h) Installations with dampered combustion air openings shall prove damper open position before trial for burner ignition.
   (i) Vent dampers and flue dampers shall be interlocked to prevent burner ignition unless safely open.
   (j) One high oil or liquid fuel-pressure interlock, reset from flame safeguard or manually.
(k) Where hot water or steam, two low water cutoffs.
(l) An atomizing medium proving switch.
(m) A low oil temperature switch for oil or liquid fuel requiring preheating.
(n) A high oil temperature interlock for oil or liquid fuel requiring preheating.
(o) The burner oil pump shall automatically not operate or rotate while the alternate fuel is firing.
(p) A pressure-relief valve shall be provided between safety shutoff valves and between pump and safety valves where an integral valve is used with a pump.
(q) A separate relief device is required on each transfer pump.
(r) One low oil or liquid fuel-pressure interlock, reset from flame safeguard or manually.
(s) Burners with automatic controls, prepurge, proof-of-closure, modulation, or postpurge shall not use relays external to the flame safeguard to accomplish these functions.

(4) Two million five hundred thousand to 12 499 999 Btu/h (733 kW to 3663.3 kW) per burner.
(a) One approved manual shutoff valve lever handle.
(b) One approved fuel-oil filter, installed on the supply piping.
(c) Two safety shutoff valves in series, with a combined flame failure response and valve closing time not to exceed 5 seconds with strainer directly before the valves.
(d) Programmed electronic flame safeguard including proven low-fire start, manual reset lockout, 100 percent shutoff (both pilot and main burner), and a separately supervised and proven pilot.
Flame-sensing systems utilizing a UV scanner shall prove pilot and interrupt ignition spark prior to main burner valves being energized.
(e) Two controls, one operating and one high limit, activated by temperature or pressure.
(f) Burners relying on mechanical means to provide air for combustion shall have actual proof-of-air interlock device.
(g) Power burners shall include proven prepurge of not less than 60 seconds at high-fire damper settings. This prepurge shall occur before every burner cycle, regardless of reason.
(h) Installations with dampered combustion air openings shall prove damper open position before trial for burner ignition.
(i) Vent dampers and flue dampers shall be interlocked to prevent burner ignition unless safely open.
(j) One high oil or liquid fuel-pressure interlock, reset from flame safeguard or manually.
(k) Where hot water or steam, two low water cutoffs.

(l) An atomizing medium proving switch.
(m) A low oil temperature switch for oil or liquid fuel requiring preheating.
(n) A high oil temperature interlock for oil or liquid fuel requiring preheating.
(o) A separate firing rate control valve.
(p) The burner oil pump shall automatically not operate or rotate while the alternate fuel is firing.
(q) A pressure-relief valve shall be provided between safety shutoff valves and between pump and safety valves where an integral valve is used with a pump.
(r) A separate relief device is required on each transfer pump.
(s) One low oil or liquid fuel-pressure interlock reset from flame safeguard or manually.
(t) Burners with automatic controls, prepurge, proof-of-closure, modulation, or postpurge shall not use relays external to the flame safeguard to accomplish these functions.

(5) More than 12 500 000 Btu/h (3663.4 kW) per burner inputs. These burners shall comply with the requirements of the appropriate standards listed in Chapter 17 and the following:
(a) One approved manual shutoff valve lever handle.
(b) One approved fuel-oil filter, installed on the supply piping.
(c) Two safety shutoff valves in series, one with proof of closure, with a combined flame failure response and valve closing time not to exceed 2 seconds with strainer directly before the valves.
(d) Programmed electronic flame safeguard including proven low-fire start, manual reset lockout, 100 percent shutoff (both pilot and main burner), and a separately supervised and proven pilot.
Flame-sensing systems utilizing a UV scanner shall prove pilot and interrupt ignition spark prior to main burner valves being energized.
(e) Two controls, one operating and one high limit, activated by temperature or pressure.
(f) Burners relying on mechanical means to provide air for combustion shall have actual proof-of-air interlock device.
(g) Power burners must include proven prepurge of not less than 60 seconds at high-fire damper settings. This prepurge shall occur before every burner cycle, regardless of reason.
(h) Installations with dampered combustion air openings shall prove damper open position before trial for burner ignition.
(i) Vent dampers and flue dampers shall be interlocked to prevent burner ignition unless safely open.
(j) One high oil or liquid fuel-pressure interlock; reset from flame safeguard or manually.
(k) A manual firing cock.
(l) Where hot water or steam, two low water cut-offs.
(m) An atomizing medium proving switch.
(n) A low oil temperature switch for oil or liquid fuel requiring preheating.
(o) A high oil temperature interlock for oil or liquid fuel requiring pre-heating.
(p) A separate firing rate control valve.
(q) The burner oil pump shall automatically not operate or rotate while the alternate fuel is firing.
(r) An integral valve shall be provided between safety shutoff valves and between pump and safety valves where an integral valve is used with a pump.
(s) A separate relief device is required on each transfer pump.
(t) One low oil or liquid fuel-pressure interlock, reset from flame safeguard or manually.
(u) Burners with automatic controls, prepurge, proof-of-closure, modulation, or postpurge shall not use relays external to the flame safeguard to accomplish these functions.

(6) Shutoff Valve.

(a) Oil or liquid fuel burner installations shall include a non-electric shutoff valve that is held open by a fusible link designed to close at 165°F (74°C), installed near the burner in the same room as the burner. This shall prevent the flow of oil or liquid fuel to the burner through the supply pipe. A check valve is required in the return line if the tank is higher than the burner.
APPENDIX D
FUEL SUPPLY: MANUFACTURED/MOBILE HOME PARKS AND RECREATIONAL VEHICLE PARKS

D 101.0 Fuel Gas Piping Systems.
D 101.1 General. All fuel gas piping systems serving manufactured homes, accessory buildings, or structures and communities shall be designed and constructed in accordance with any applicable provisions of NFPA 54 and NFPA 58. NFPA 31 shall apply to oil fuel-burning systems and shall comply with the criteria of the Authority Having Jurisdiction. [NFPA 501A:4.1.1.1 – 4.1.1.2]

D 101.2 Gas Supply Connections. Gas supply connections at sites, where provided from an underground gas supply piping system, shall be located and arranged to permit attachment to a manufactured home (M/H) occupying the site. For the installation of liquefied petroleum gas (LP-Gas) storage systems, the applicable provisions of NFPA 58 shall be followed. [NFPA 501A:4.1.2.1 – 4.1.2.2]

D 101.3 Location of Gas Supply Connection. The gas supply to the M/H manufactured home shall be located within 4 feet (1219 mm) of the M/H manufactured home stand.

Exception: The requirement of Section D 101.3 shall not apply to gas supply connections for manufactured homes located on all-weather wood, concrete, or concrete block foundation systems or on foundations constructed in accordance with the local building code or, in the absence of a local code, with a recognized model building code. [NFPA 501A:4.1.3]

D 101.4 Recreational Vehicle Park Fuel-Gas Equipment and Installations. Fuel gas equipment and installations shall comply with this appendix, except as otherwise permitted or required by this code.

D 102.0 Single and Multiple Manufactured Home Site Fuel Supply Systems.
D 102.1 Underground Installation. Underground gas piping system installations shall comply with any applicable building code and Section D 102.1 and Section D 102.1.2. [NFPA 501A:4.2.1.1]

D 102.1.1 Open-Ended Gastight Conduit. Underground gas piping shall not be installed beneath that portion of a M/H manufactured home site reserved for the location of a manufactured home or M/H accessory building or structure unless installed in the open-ended gastight conduit of Section D 102.1.2. [NFPA 501A:4.2.1.1]

D 102.1.2 Requirements. The open-ended gastight conduit shall comply with the requirements in the following:

(1) The conduit shall be not less than Schedule 40 pipe that is approved for underground installation beneath buildings.

(2) The interior diameter of the conduit shall be not less than 1/2 an inch (15 mm) larger than the outside diameter of the gas piping.

(3) The conduit shall extend to a point not less than 4 inches (102 mm) beyond the outside wall of the M/H, manufactured home or accessory building, or structure, and the outer ends shall not be sealed.

(4) Where the conduit terminates within a M/H manufactured home or accessory building, it shall be accessible, and the space between the conduit and the gas piping shall be sealed to prevent leakage of gas into the building. [NFPA 501A:4.2.1.2 – 4.2.1.2.4]

D 103.0 Manufactured Home Site Gas Shutoff Valve.
D 103.1 General. Each M/H manufactured home site shall have a listed gas shutoff valve installed upstream of the M/H manufactured home site gas outlet. The gas shutoff valve shall be located on the outlet riser at a height of not less than 6 inches (152 mm) above grade. A gas shutoff valve shall not be located under a M/H any manufactured home. The outlet shall be equipped with a cap or plug to prevent discharge of gas whenever the M/H manufactured home site outlet is not connected to a M/H manufactured home. [NFPA 501A:4.2.2.1 – 4.2.2.2.4]

Exception: Gas shutoff valves shall conform to Section D 103.1, except for manufactured homes located on foundations constructed in accordance with the local building code or, in the absence of a local code, with a recognized model building code. [NFPA 501A:4.2.2]

D 104.0 Gas Meters.
D 104.1 Support of Meters. Where installed, gas meters shall be supported by a post or bracket placed on a firm footing or other means providing equivalent support and shall not depend on the gas outlet riser for support. [NFPA 501A:4.2.3.1.1]

D 104.2 Location of Meters. Each gas meter shall be installed in an accessible location and shall be provided with unions or other fittings so that the meter can be removed easily and replaced in an upright position. Meters shall not be installed in unventilated or inaccessible locations or closer than 3 feet (914 mm) to sources of ignition. [NFPA 501A:4.2.3.2.1 – 4.2.3.2.2]

D 104.3 Meter Shutoff Valve or Cock. All gas meter installations shall be provided with shutoff valves or cocks located adjacent to and on the inlet side of the meters. In the case of a single meter installation utilizing an LP-Gas container, the container service valve shall be permitted to be used in lieu of the shutoff valve or cock. All gas meter installations shall be provided with test tees located adjacent to and on the outlet side of the meters. [NFPA 501A:4.2.4.1 – 4.2.4.3]
D 105.0 Cathodic Protection Requirements.

D 105.1 General. Cathodic protection shall be installed for corrosion control of buried or submerged metallic gas piping in accordance with the following requirements:

1. Where amphoteric metals are included in a buried or submerged pipeline containing a metal of different anodic potential the following protection shall be provided:
   a. The buried or submerged pipeline shall be cathodically protected at a negative (cathodic) voltage of 0.85 volt, measured between the structure surface and a saturated copper-copper sulfate half cell contacting the electrolyte.
   b. The amphoteric metals shall be electrically isolated from the remainder of the pipeline with insulating flanges, or equivalent, and cathodically protected.

2. The amount of cathodic protection shall be such that the protective coating and the pipe are not damaged.

D 106.0 Manufactured Home Community LPG Supply Systems.

D 106.1 General. Where 10 or more customers are served by one LPG supply system, the installation of the gas supply system shall be in accordance with 49 CFR 192. Other types of liquefied petroleum gas systems and the storage and handling of LPG shall be in accordance with NFPA 58 (see Section D 4.3.1), [NFPA 501A:4.3.2.1 – 4.3.2.2]

D 107.0 Required Gas Supply.

D 107.1 General. The minimum hourly volume of gas required at each manufactured home site outlet or any section of the manufactured home community gas piping system shall be calculated as shown in Table D 107.1. [NFPA 501A:4.3.4.1]

In extreme climate areas, additional capacities other than those shown in Table D 107.1 shall be considered.

D 108.0 Gas Pipe Sizing and Pressure.

D 108.1 Size. The size of each section of a gas piping system shall be determined in accordance with NFPA 54, or by other standard engineering methods acceptable to the Authority Having Jurisdiction. [NFPA 501A:4.3.5.1]

D 108.2 Pressure. Where all connected appliances are operated at their rated capacity, the gas supply pressure shall be not less than 7 inches of water column (1.7 kPa). The gas supply pressure shall not exceed 14 inches of water column (3.5 kPa). [NFPA 501A:4.3.5.2]

D 109.0 Gas Piping Materials.

D 109.1 Metal. Metal gas pipe shall be standard-weight wrought iron or steel (galvanized or black), yellow brass containing not more than 75 percent copper, or internally tinned or treated copper of iron pipe size. Galvanizing shall not be considered protection against corrosion.

Seamless copper or steel tubing shall be permitted to be used with gases not corrosive to such material. Steel tubing shall comply with ASTM A254. Copper tubing shall comply with ASTM A280 (Type B or Type K). Copper tubing (unless tin-lined) shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet (0.7 mg/100 L) of gas. [NFPA 501A:4.3.6.3]

D 109.2 Protection Coatings for Metal Gas Piping. All gas pipe protective coatings shall be approved types, shall be machine applied, and shall comply with conform to recognized standards. Field wrapping shall provide equivalent protection and is restricted to those short sections and fittings that are necessarily stripped for threading or welding. Risers shall be coated or wrapped to a point at least 6 inches (152 mm) aboveground. [NFPA 501A:4.3.6.2 – 4.3.6.2.4]

D 109.3 Plastic. Plastic piping shall only be used underground and shall meet the requirements of ASTM D2513 or ASTM D2517, as well as the design pressure and design limitations of 49 CFR (Section 192.123), and shall otherwise conform to the installation requirements thereof. [NFPA 501A:4.3.6.3]

D 110.0 Gas Piping Installations.

D 110.1 Minimum Burial Below Ground Level and Clearances. All gas piping installed belowground level shall have a minimum earth cover of not less than 18 inches (457 mm) and shall be installed with not less than least 12 inches (305 mm) of clearance in any direction from any other underground utility systems. [NFPA 501A:4.3.7.1]

D 110.2 Metallic Gas Piping. All metallic gas piping systems shall be installed in accordance with approved en
APPENDIX D

D 110.2.1 Cathodic Protection. Where the cathodic protection system is designed to protect only the gas piping system, the gas piping system shall be electrically isolated from all other underground metallic systems or installations. Where only the gas piping system is cathodically protected against corrosion, a dielectric fitting shall be used in the manufactured home gas connection to insulate the manufactured home from the underground gas piping system. [NFPA 501A:4.3.7.2.3, 4.3.7.2.4]

D 110.2.2 Underground Metallic Systems. Where a cathodic protection system is designed to provide all underground metallic systems and installations with protection against corrosion, all such systems and installations shall be electrically bonded together and protected as a whole. [NFPA 501A:4.3.7.2.5]

D 110.3 Plastic Gas Piping. Plastic gas piping shall be used underground and shall be installed with an electrically conductive wire for locating the pipe. The wire used to locate the plastic pipe shall be copper, not less smaller in size than No. 18 AWG, with insulation approved for direct burial. Every portion of a plastic gas piping system consisting of metallic pipe shall be cathodically protected against corrosion. [NFPA 501A:4.3.7.3.1 – 4.3.7.3.3]

D 110.4 Gas Piping System Shutoff Valve. An accessible and identifiable shutoff valve controlling the flow of gas to the entire manufactured home community gas piping system shall be installed in a location approved by acceptable to the Authority Having Jurisdiction and near the point of connection to the service piping or to the supply connection of an LP-Gas container. [NFPA 501A:4.3.7.4]

D 111.0 Liquefied Petroleum Gas Appliances.

D 111.1 General. LP-Gas equipment shall be installed in accordance with the applicable provisions of NFPA 58. [NFPA 501A:4.3.8]

D 112.0 Oil Supply.

D 112.1 General. The following three methods of supplying oil to an individual manufactured home site shall be permitted:

1. Supply from an outside underground tank (see Section D 113.6).
2. Supply from a centralized oil distribution system designed and installed in accordance with accepted engineering practices and in compliance with NFPA 31.
3. Supply from an outside aboveground tank (see Section D 113.6). [NFPA 501A:4.3.9]

D 112.2 Minimum Oil Supply Tank Size. Oil supply tanks shall have a minimum capacity equal to 20 percent of the average annual oil consumption. [NFPA 501A:4.3.10]

D 112.3 Oil Supply Connections. Oil supply connections at manufactured home sites, where provided from a central-ized oil distribution system, shall be located and arranged to permit attachment to a manufactured home utilizing the stand. [NFPA 501A:4.3.11.1] The installation of such facilities shall comply with the following requirements:

1. The main distribution pipeline shall be permitted to be connected to a tank or tanks having an aggregate capacity not exceeding 20 000 gallons (75 708 L) at a point below the liquid level.
2. Where this piping is so connected, a readily accessible internal or external shutoff valve shall be installed in the piping as close as practicable to the tank.
3. If external and aboveground, the shutoff valve and its tank connections shall be made of steel.
4. Connections between the tank(s) and the main pipeline shall be made with double swing joints or flexible connectors, or shall otherwise be arranged to permit the tank(s) to settle without damaging the system.
5. If located aboveground, the connections specified in Section D 112.3(4) shall be located within the diked area.
6. A readily accessible and identified manual shutoff valve shall be installed either inside or outside of the structure in each branch supply pipeline that enters a building, mobile home, travel trailer, or other structure. If outside, the valve shall be protected from weather and damage. If inside, the valve shall be located directly adjacent to the point at which the supply line enters the structure.
7. A device shall be provided in the supply line at or ahead of the point where it enters the interior of the structure that will automatically shut off the oil supply, if the supply line between this device and the appliance is broken. This device shall be located on the appliance side of the manual shutoff valve required in Section D 112.3(6) and shall be solidly supported and protected from damage.
8. Means shall be provided to limit the oil pressure at the appliance inlet to a maximum gauge pressure of 3 pound-force per square inch gauge (psig) (21 kPa). If a pressure-reducing valve is used, it shall be a type approved for the service.
9. A device shall be provided that will automatically shut off the oil supply to the appliance if the oil pressure at the appliance inlet exceeds a gauge pressure of 8 psig (55 kPa). The device shall not be required under either of the following conditions:
   a. Where the distribution system is supplied from a gravity tank and the maximum hydrostatic head of oil in the tank is such that the oil pressure at the appliance inlet will not exceed a gauge pressure of 8 psig (55 kPa).
   b. Where a means is provided to automatically shut off the oil supply if the pressure-regulating device provided in accordance with Section D 112.3(8) fails to regulate the pressure as required.
10. Only appliances equipped with primary safety controls specifically listed for the appliance shall be connected to a centralized oil distribution system. [NFPA 31:9.2.10–9.2.15]
D 113.0 Fuel Supply Systems Installation.

D 113.1 Flexible Gas Connector. Except for manufactured homes located on an all-weather wood, concrete, or concrete block foundation system or on a foundation constructed in accordance with the local building code or, in the absence of a local code, with a recognized model building code, each gas supply connector shall be listed for outside manufactured home use, shall be not more than 6 feet (1829 mm) in length, and shall have a capacity rating to supply the connected load. [NFPA 501A:4.4.1]

D 113.2 Use of Approved Pipe and Fittings of Extension. Where it is necessary to extend the M/H manufactured home inlet to permit connection of the 6 foot (1829 mm) listed connector to the site gas outlet, the extension shall be of approved materials of the same size as the M/H manufactured home inlet and shall be adequately supported at no more than 4 foot (1219 mm) intervals to the M/H manufactured home. [NFPA 501A:4.4.2]

D 113.3 Mechanical Protection. All gas outlet risers, regulators, meters, valves, and other exposed equipment shall be protected against accidental damage. [NFPA 501A:4.4.3]

D 113.4 Special Rules on Atmospherically Controlled Regulators. Atmospherically controlled regulators shall be installed in such a manner that moisture cannot enter the regulator vent and accumulate above the diaphragm. Where the regulator vent is obstructed due to snow and icing conditions, shields, hoods, or other approved suitable devices shall be provided to guard against closing of the vent opening. [NFPA 501A:4.4.4.1 – 4.4.4.2]

D 113.5 Fuel Gas Piping Test. The M/H manufactured home fuel gas piping system shall be tested only with air before it is connected to the gas supply. The M/H manufactured home gas piping system shall be subjected to a pressure test with all appliance shutoff valves in their closed positions. [NFPA 501A:4.4.5]

D 113.5.1 Procedures. The fuel gas piping test shall consist of air pressure not less than 10 inches water column or more than 14 inches water column (2.5 kPa to 3.5 kPa). The fuel gas piping system shall be isolated from the air pressure source and shall maintain this pressure for not less than 10 minutes without perceptible leakage. Upon satisfactory completion of the fuel gas piping test, the appliance valves shall be opened; and the gas appliance connectors shall be tested with soapy water or bubble solution while under the pressure remaining in the piping system. Solutions used for testing for leakage shall not contain corrosive chemicals. Pressure shall be measured with either a manometer, slope gauge, or gauge that is calibrated in either water inch (mm) or psi (kPa); with increments of either 1/10 of an inch (2.5 mm) or 1/10 psi (0.7 kPa) gauge, as applicable. Upon satisfactory completion of the fuel gas piping test, the M/H manufactured home gas supply connector shall be installed; and the connections shall be tested with soapy water or bubble solution. [NFPA 501A:4.4.5.1 – 4.4.5.1.6]

D 113.5.2 Warning. The following warning shall be supplied to the installer:

**WARNING:** Do not overpressurize the fuel gas piping system. Damage to valves, regulators, and appliances is capable of occurring due to pressurization beyond the maximums specified. [NFPA 501A:4.4.5.2]

D 113.5.3 Vents. Gas appliance vents shall be visually inspected to ensure that they have not been dislodged in transit and are connected securely to the appliance. [NFPA 501A:4.4.5.3]

D 113.6 Oil Tanks. Oil tank capacities shall comply with the following:

1. No oil tank capacity shall exceed 660 gallons (2498 L) or less shall be connected to one oil-burning appliance. [NFPA 501A:4.4.6.1]

2. Two supply tanks, where used, shall be cross-connected and provided with a single fill and single vent, in accordance with those described in NFPA 31, and shall be on a common slab and rigidly secured, one to the other. [NFPA 501A:4.4.6.2]

3. Tanks having a capacity of 660 gallons (2498 L) or less shall be securely supported by rigid, noncombustible supports to prevent settling, sliding, or lifting. [NFPA 501A:4.4.6.3]

D 113.6.1 Installation. Oil supply tanks shall be installed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.4.6.1.1]

D 113.6.2 Capacity. A tank with a capacity no larger than 60 gallons (227 L) shall be permitted to be a DOT-5 shipping container (drum), and so marked, or a tank constructed in accordance with the provisions of UL 80. Tanks other than DOT-5 shipping containers having a capacity of not more than 660 gallons (2498 L) shall be constructed in accordance with the provisions of UL 80. Pressure tanks shall be constructed in accordance with Section VIII, Pressure Vessels, of the ASME Boiler and Pressure Vessel Code. [NFPA 501A:4.4.6.2.1 – 4.4.6.2.2]

D 113.6.3 Location. Tanks, as described in Section D 113.6 and Section D 113.6.2, that are adjacent to buildings shall be located not less than 10 feet (3048 mm) from a property line that is permitted to be built upon. [NFPA 501A:4.4.6.3]

D 113.6.4 Vent. Tanks with a capacity no larger than 660 gallons (2498 L) shall be equipped with an open vent no smaller than 1/4 inch (32 mm) iron pipe size; tanks with a 500 gallon (1892 L) or less capacity shall have a vent of 1/4 inch (32 mm) iron pipe size. [NFPA 501A:4.4.6.4]

D 113.6.5 Liquid Level. Tanks shall be provided with a means of determining the liquid level. [NFPA 501A:4.4.6.5]

D 113.6.6 Fill Opening. The fill opening shall be a size and in a location that permits filling without spillage. [NFPA 501A:4.4.6.6]
D 114.0 Manufactured Home Accessory Building Fuel Supply Systems.

D 114.1 General. Fuel gas supply systems installed in a Manufactured home accessory building or structure shall be in accordance with the applicable provisions of NFPA 54 and NFPA 58. Fuel oil supply systems shall comply with the applicable provisions of NFPA 31. [NFPA 501A:4.5.1 – 4.5.2]

D 115.0 Community Building Fuel Supply Systems in Manufactured Home Communities.

D 115.1 Fuel Gas Piping and Equipment Installations. Fuel gas piping and equipment installed within a permanent building in a Manufactured home community shall be in accordance with nationally recognized appliance and fuel gas piping codes and standards adopted by the Authority Having Jurisdiction. Where the state or other political subdivision does not assume jurisdiction, such fuel gas piping and equipment installations shall be designed and installed in accordance with the applicable provisions of NFPA 54 or NFPA 58. [NFPA 501A:4.6.1.1 – 4.6.1.2]

D 115.2 Oil Supply Systems in Manufactured Home Communities. Oil-burning equipment and installations within a Manufactured home community shall be designed and constructed in accordance with the applicable codes and standards adopted by the Authority Having Jurisdiction. Where the state or other political subdivision does not assume jurisdiction, such installations shall be designed and constructed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.6.2.1 – 4.6.2.2]

D 115.3 Oil-Burning Equipment and Installation. Oil-burning equipment and installations within a building constructed in a Manufactured home community in accordance with the local building code or a nationally recognized building code shall be in accordance with nationally recognized codes and standards adopted by the Authority Having Jurisdiction. Where the state or other political subdivision does not assume jurisdiction, such oil-burning equipment and installations shall be designed and installed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.6.3.1 – 4.6.3.2]

D 115.4 Inspection and Tests. Inspections and tests for fuel gas piping shall be made in accordance with Chapter 1 and Chapter 13 of this code.
APPENDIX E
SUSTAINABLE PRACTICES

E 101.0 General.

E 101.1 Applicability. The purpose of this appendix is to provide a comprehensive set of technically sound provisions that encourage sustainable practices and works towards enhancing the design and construction of mechanical systems that result in a positive long-term environmental impact. This appendix is not intended to circumvent the health, safety, and general welfare requirements of this code.

E 101.2 Definition of Terms. For the purposes of this code, the definitions shall apply to this appendix.

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 appendix to avoid misunderstanding.

The definitions of terms are arranged alphabetically according to the first word of the term.

E 201.0 Definitions.

E 201.1 Cycles of Concentration for Cooling Towers. Cycles of concentration equals the specific conductance of the water in the cooling tower basin divided by the combined flow-weighted average specific conductance of the makeup water(s) to the cooling tower.

E 201.2 Duct Wall Penetrations. Includes pipe, tubing, rods, and wire. Screws and other fasteners are not considered to be ductwork penetrations.

E 201.3 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.

E 201.4 Geothermal. Renewable energy generated by deep-earth.

E 201.5 Heating Seasonal Performance Factor (HSPF). The total heating output of a heat pump during its normal annual usage period for heating in British thermal units (Btu) (kW•h) divided by the total electric energy input during the same period. [ASHRAE 90.1:3.2]

E 201.6 Integrated Energy Efficiency Ratio (IEER). A single-number figure of merit expressing cooling part-load EER efficiency for commercial unitary air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment. [ASHRAE 90.1:3.2]

E 201.7 Integrated Part-Load Value (IPLV). A single-number figure of merit based on part-load EER, COP<sub>0</sub> or kW<sub>cool</sub>/kW expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment. [ASHRAE 90.1:3.2]

E 201.8 Joint, Transverse. Connections of two duct sections oriented perpendicular to airflow.

E 201.9 Maintenance. The upkeep of property or equipment by the owner of the property in accordance with the requirements of this appendix.

E 201.10 Minimum Efficiency Reporting Value (MERV). Filter minimum efficiency reporting value, in accordance with ASHRAE 52.2.

E 201.11 Multi-Occupant Spaces. Indoor spaces used for presentations and training, including classrooms and conference rooms.

E 201.12 Recirculation System. A system of hot water supply and return piping with shutoff valves, balancing valves, circulating pumps, and a method of controlling the circulating system.


E 201.14 Seasonal Energy Efficiency Ratio (SEER). The total cooling output of an air conditioner during its normal annual usage period for cooling in Btu (kW•h) divided by the total electric energy input during the same period in Btu (kW•h). [ASHRAE 90.1:3.2]

E 301.0 General Regulations.

E 301.1 Installation. Mechanical 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 301.2 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 302.0 Disposal of Liquid Waste.

E 302.1 Disposal. It shall be unlawful for a person to cause, suffer, or permit the disposal of liquid wastes, in a place or manner, except through and by means of an approved drainage system, installed and maintained in accordance with the provisions of the plumbing code.

E 302.2 Connections to Plumbing System Required. Equipment and appliances, used to receive or discharge liquid wastes or sewage, shall be connected to the drainage system of the building or premises in accordance with the requirements of the plumbing code and this appendix.

E 303.0 Abandonment.

E 303.1 General. An abandoned system or part thereof covered under the scope of this appendix shall be disconnected from remaining systems, drained, plugged, and capped in an approved manner.
E 401.0 Water Conservation and Efficiency.

E 401.1 General. The provisions of this section establish the means of conserving potable and nonpotable water used in and around a building.

E 402.0 Meters.

E 402.1 Required. A water meter shall be required for buildings connected to a public water system, including municipally supplied reclaimed (recycled) water. In other than single-family houses, multi-family structures not exceeding three stories above grade, and modular houses, a separate meter or submeter shall be installed in the following locations:

1. The makeup water supply to cooling towers, evaporative condensers, and fluid coolers.
2. The makeup water supply to one or more boilers collectively exceeding 1 000 000 British thermal units per hour (Btu/h) (293 kW).
3. The water supply to a water-using process where the consumption exceeds 1000 gallons per day (gal/d) (0.0438 L/s), except for manufacturing processes.
4. The makeup water supply to an evaporative cooler having an air flow exceeding 30 000 cubic feet per minute (cfm) (14.158 m³/s).

E 402.2 Consumption Data. A means of communicating water consumption data from submeters to the water consumer shall be provided.

E 402.3 Access. Meters and submeters shall be accessible.

E 403.0 HVAC Water Use.

E 403.1 Once-Through Cooling. Once-through cooling using potable water is prohibited.

E 403.2 Cooling Towers and Evaporative Coolers. Cooling towers and evaporative coolers shall be equipped with makeup water and blow down meters, conductivity controllers, and overflow alarms. Cooling towers shall be equipped with efficiency drift eliminators that achieve drift reduction to 0.002 percent of the circulated water volume for counterflow towers and 0.005 percent for cross-flow towers.

E 403.3 Cooling Tower Makeup Water. Not less than 5 cycles of concentration is required for air-conditioning cooling tower makeup water having a total hardness of less than 11 grains per gallon (gr/gal) (188 mg/L) expressed as calcium carbonate. Not less than 3.5 cycles of concentration is required for air-conditioning cooling tower makeup water having a total hardness equal to or exceeding 11 gr/gal (188 mg/L) expressed as calcium carbonate.

Exception: Air-conditioning cooling tower makeup water having discharge conductivity range not less than 7 gr/gal (120 mg/L) to 9 gr/gal (154 mg/L) of silica measured as silicon dioxide.

E 403.4 Evaporative Cooler Water Use. Evaporative cooling systems shall use 3.5 gallons (13.2 L) or less of water per ton-hour (kW•h) of cooling where system controls are set to maximum water use. Water use expressed in maximum water use per ton-hour (kW•h) of cooling, shall be marked on the device and included in the product user manual, product information literature, and manufacturer’s installation instructions. Water use information shall be readily available at the time of code compliance inspection.

E 403.4.1 Overflow Alarm. Cooling systems shall be equipped with an overflow alarm to alert building owners, tenants, or maintenance personnel where the water refill valve continues to allow water to flow into the reservoir where the reservoir is full. The alarm shall have a sound pressure level rating of not less than 85 dBA measured at a distance of 10 feet (3048 mm).

E 403.4.2 Automatic Pump Shut-Off. Cooling systems shall automatically cease pumping water to the evaporation pads where airflow across evaporation pads ceases.

E 403.4.3 Cooler Reservoir Discharge. A water quality management system (either timer or water quality sensor) shall be provided. Where timers are used, the time interval between discharge of reservoir water shall be set to 6 or more hours of cooler operation. Where water quality sensors are used, the discharge of reservoir water shall be set for 800 ppm or more of total dissolved solids (TDS). Continuous discharge or continuous bleed systems shall not be installed.

E 403.4.4 Discharge Water Reuse. Discharge water shall be reused where applications exist on site. Where a nonpotable water source system exists on site, evaporative cooler discharge water shall be collected and discharged to the collection system.

Exception: Where the reservoir water affects the quality of the nonpotable water supply making the nonpotable water unusable for its intended purposes.

E 403.4.5 Discharge Water to Drain. Where discharge water is not recovered for reuse, the sump overflow line shall not be directly connected to a drain. Where the discharge water is discharged into a sanitary drain, an air gap of not less than 6 inches (152 mm) shall be provided between the termination of the discharge line and the drain opening. The discharge line shall terminate in a location that is visible to the building owner, tenants, or maintenance personnel.

E 403.5 Use of Reclaimed (Recycled) and On-Site 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 403.5.1 Drift Eliminator. A drift eliminator shall be utilized in a cooling system, utilizing alternate sources of water, where the aerosolized water is capable of coming in contact with employees or members of the public.

E 403.5.2 Disinfection. A biocide shall be used to treat the cooling system recirculation water where the recycled water is capable of coming in contact with employees or members of the public.

E 501.1 Scope. The provisions of this section shall establish the means of enhancing energy efficiency associated with mechanical systems in a building.


E 502.1 General. The heating, ventilating, air-conditioning, for single-family houses, multi-family structures not exceeding three stories above grade, and modular houses shall be in accordance with Section E 502.2 through Section E 502.12. The heating, ventilation, and air-conditioning system of other buildings shall be in accordance with Section E 503.0.

E 502.2 Heating, Ventilating, and Air-Conditioning Systems and Equipment. This section shall regulate only equipment using single-phase electric power, air conditioners, and heat pumps with rated cooling capacities less than 65 000 Btu/h (19 kW), warm air furnaces with rated heating capacities less than 225 000 Btu/h (66 kW), boilers less than 300 000 Btu/h (88 kW) input, and heating-only heat pumps with rated heating capacities less than 65 000 Btu/h (19 kW). [ASHRAE 90.2:6.2]

E 502.2.1 Non-Residential Type Systems and Equipment. Heating, ventilating, and air-conditioning systems and equipment that do not fall under the requirements of Section E 502.0 shall be in accordance with the applicable requirements of Section E 503.0.

E 502.3 Balancing. The air distribution system design, including outlet grilles, shall provide a means for balancing the air distribution system unless the design procedure provides a system intended to operate within plus or minus 10 percent of design air quantities. [ASHRAE 90.2:6.3]

E 502.3.1 Balancing Dampers. Balancing dampers shall be installed in branch ducts, and the axis of the damper shall be installed parallel to the direction of airflow in the main duct.

E 502.4 Ducts. Ducts shall be sized, installed, and tested in accordance with Section E 502.4.1 through Section E 502.4.4.

E 502.4.1 Insulation for Ducts. Portions of the air distribution system installed in or on buildings for heating and cooling shall be R-8. Where the mean outdoor dew-point temperature in a month exceeds 60°F (16°C), vapor retarders shall be installed on conditioned-air supply ducts. Vapor retarders shall have a water vapor permeance not exceeding 0.5 perm [2.87 E-11 kg/(Pa•s•m2)] where tested in accordance with Procedure A in ASTM E96.

Insulation shall not be required where the ducts are within the conditioned space. [ASHRAE 90.2:6.4]

E 502.4.2 Ducts and Register Penetrations. Joints, seams, and penetrations of duct systems shall be made airtight by means of mastics, gasketing, or other means in accordance with this code. Register penetrations shall be sealed to the wall or floor assemblies. Where HVAC duct penetrates a conditioned space, the duct penetration shall be sealed to the wall or floor assembly to prevent leakage into an unconditioned space.

E 502.4.3 Duct Leakage Test. For systems with a duct or air handler outside of the conditioned space, a duct leakage test shall be performed in accordance with Section E 502.4.3.1.

E 502.4.3.1 Duct Leakage Verification Test. Ductwork shall be tested to the maximum permitted leakage in 1 cubic foot per minute (ft³/min) per 100 square feet [0.0001 (m³/s)/m²] of duct surface area in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Register penetrations shall be sealed during the test. The test shall be conducted with a pressure differential of 0.1 inch water gauge (0.02 kPa) across the tested system.

E 502.4.4 Duct Sizing. Duct systems shall be sized in accordance with ACCA Manual D or other methods approved by the Authority Having Jurisdiction with the velocity in the main duct not to exceed 1000 feet per minute (ft/min) (5.08 m/s) and the velocity in the secondary branch duct not to exceed 600 ft/min (3.048 m/s).

E 502.5 Insulation for Piping. HVAC system piping installed to serve buildings and within buildings shall be thermally insulated in accordance with Table E 502.5. [ASHRAE 90.2:6.5]

E 502.6 Ventilation and Combustion Air. The building shall be designed to have the capability to provide the ventilation air specified in Table E 502.6. Mechanical ventilation shall be calculated in accordance with Equation E 502.6.

(Equation E 502.6)

\[
\text{Mechanical Ventilation} = \frac{(0.35 \times \text{Summer}) \times \text{Volume}}{60}
\]

Where:

\[
\text{Mechanical Ventilation} = \text{required mechanical ventilation rate to supplement summer infiltration, cfm (m³/s)}
\]

\[
\text{Summer} = \text{summer design infiltration rate, ACH}
\]

\[
\text{Volume} = \text{volume of conditioned space, ft}^3(\text{m}^3)
\]

E 502.6.1 Combustion Air. Combustion air for fossil fuel heating equipment shall comply with this code or with one of the following:

1. Natural gas and propane heating equipment, NFPA 54
2. Oil heating equipment, NFPA 31
3. Solid fuel burning equipment, NFPA 211 [ASHRAE 90.2:6.6.2]

E 502.7 Electric Heating Systems. Electric heating systems shall be installed in accordance with the following requirements. [ASHRAE 90.2:6.7]
E 502.7.1 Wall, Floor, or Ceiling Electric-Resistance Heating. Where wall, floor, or ceiling electric-resistance heating units are used, the structure shall be zoned and heaters installed in each zone in accordance with the heat loss of that zone. Where living and sleeping zones are separate, the number of zones shall be not less than two. Where two or more heaters are installed in one room, they shall be controlled by one thermostat. [ASHRAE 90.2:6.7.1]

E 502.7.2 Electric Central Warm Air Heating. Where electric central warm air heating is to be installed, an electric heat pump or an off-peak electric heating system with thermal storage shall be used.

Exceptions:
1. Electric resistance furnaces where the ducts are located inside the conditioned space, and not less than two zones are provided where the living and sleeping zones are separate.
2. Packaged air-conditioning units with supplemental electric heat. [ASHRAE 90.2:6.7.2]

E 502.8 Bath Ceiling Units. Bath ceiling units providing a combination of heat, light, or ventilation shall be provided with controls permitting separate operation of the heating function. [ASHRAE 90.2:6.8]

### Table E 502.5

<table>
<thead>
<tr>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE DIAMETER (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLUID DESIGN OPERATING TEMPERATURE RANGE (°F)</strong></td>
<td><strong>MEAN RATING TEMPERATURE (°F)</strong></td>
</tr>
<tr>
<td><strong>HEATING SYSTEMS (STEAM, STEAM CONDENSATE, AND HOT WATER)</strong></td>
<td></td>
</tr>
<tr>
<td>201–250</td>
<td>0.27–0.30</td>
</tr>
<tr>
<td>141–200</td>
<td>0.25–0.29</td>
</tr>
<tr>
<td>105–140</td>
<td>0.22–0.28</td>
</tr>
<tr>
<td><strong>COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)</strong></td>
<td></td>
</tr>
<tr>
<td>40–55</td>
<td>0.22–0.28</td>
</tr>
<tr>
<td>Below 40</td>
<td>0.22–0.28</td>
</tr>
</tbody>
</table>

For SI Units: °C = (°F-32)/1.8, 1 British thermal unit/square foot degree Fahrenheit = 0.1 W/(m•K), 1 inch = 25 mm

Notes:
1. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:
   \[ T = r \left( 1 + \frac{K}{k} - 1 \right) \]
   Where:
   - T = minimum insulation thickness (inches).
   - r = actual outside radius of pipe (inches) (mm).
   - t = insulation thickness listed in this table for applicable fluid temperature and pipe size.
   - K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu•in/(h•ft²•°F)] [W/(m•K)].
   - k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.
2. These thicknesses are based on energy efficiency considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.
3. Piping insulation is not required between the control valve and coil on run-outs where the control valve is located within 4 feet (1219 mm) of the coil and the pipe size is 1 inch (25 mm) or less.
4. These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders, additional insulation or both.
5. For piping exposed to outdoor air, increase insulation thickness by 1/2 of an inch (12.7 mm). The outdoor air is defined as any portion of insulation that is exposed to outdoor air. For example, attic spaces and crawl spaces are considered exposed to outdoor air.

### Table E 502.6

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MINIMUM REQUIREMENT</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical ventilation(^1)</td>
<td>50 ft(^3)/min outdoor air</td>
<td>Where summer design infiltration rate calculated in accordance with reference standard (a) or (b) is less than 0.35 ACH(^2).</td>
</tr>
<tr>
<td>Kitchen exhaust</td>
<td>100 ft(^3)/min intermittent</td>
<td>All conditions</td>
</tr>
<tr>
<td>Bath exhaust</td>
<td>intermittent</td>
<td>All conditions</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m\(^3\)/s

Notes:
2. Reference standards:
   a. ACCA Manual J
   b. ASHRAE GRP-158
E 502.9 HVAC Equipment, Rated Combinations. HVAC system equipment and system components shall be furnished with the input(s), the output(s), and the value of the appropriate performance descriptor of HVAC products in accordance with federal law or in accordance with Table E 502.9, as applicable. These shall be based on newly produced equipment or components. Manufacturer’s instructions shall be furnished with and attached to the equipment. The manufacturer of electric-resistance heating equipment shall furnish full-load energy input over the range of voltages at which the equipment is intended to operate. [ASHRAE 90.2:6.9]

E 502.10 Controls. Each system or each zone within a system shall be provided with not less than one thermostat capable of being set from 55°F (13°C) to 85°F (29°C) and capable of operating the system’s heating and cooling. The thermostat or control system, or both, shall have an adjustable dead-band, the range of which includes a setting of 10°F (6°C) between heating and cooling where automatic changeover is provided. Wall-mounted temperature controls shall be mounted on an inside wall. [ASHRAE 90.2:6.10.1]

E 502.10.1 Initial Control Setting. The control shall initially be set for a maximum heating temperature of 70°F (21°C) and a cooling temperature of not less than 78°F (26°C).

E 502.10.2 Ventilation Control. Each mechanical ventilation system (supply, exhaust, or both) shall be equipped with a readily accessible switch or other means for shut-off. Manual or automatic dampers installed for the purpose of isolating outside air intakes and exhausts from the air distribution system shall be designed for tight shut-off. [ASHRAE 90.2:6.10.2]

E 502.10.3 Humidity Control. Where additional energy-consuming equipment is provided for adding moisture to maintain specific selected relative humidities in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent energy from being used to produce a relative humidity within the space below 50 percent during periods of human occupancy and below 60 percent during unoccupied periods. [ASHRAE 90.2:6.10.3.2]

E 502.10.4 Freeze Protection Systems. Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls capable of and configured to shut off the systems where outdoor air temperatures are above 40°F (4°C) or where the conditions of the protected fluid will prevent freezing. Snow- and ice-melting systems shall include automatic controls capable of and configured to shut off the systems where the pavement temperature is above 50°F (10°C) and no precipitation is falling and an automatic or manual control that will allow shut-off where the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible. [ASHRAE 90.1:6.4.3.7]

E 502.10.5 Other Controls. Where setback, zoned, humidity and cooling controls and equipment are provided, they shall be designed and installed in accordance with Section E 502.10 through Section E 502.10.3.1. [ASHRAE 90.2:6.10.3.3]

E 502.11 Whole House Fans. Whole house exhaust fans shall have insulated louvers or covers which close where the fan is off. Covers or louvers shall have an insulation value of not less than R-4.2, and shall be installed in accordance with the manufacturer’s installation instructions. The attic openings shall be sufficient to accommodate the ventilation capacity of the whole house fan. The operation of the whole house fan shall be considered in determining the adequacy of providing combustion air in accordance with this code.

E 502.12 Dampers. Dampers shall be installed to close off outdoor air inlets and exhaust outlets where the ventilation system is not operating.

E 503.0 Heating, Ventilation, and Air-Conditioning – Other than Low-Rise Residential Buildings.

E 503.1 General. The heating, ventilation, and air-conditioning in buildings, other than single-family houses, multi-family structures of not more than three stories above grade, and modular houses, shall be in accordance with Section E 503.0.

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**TABLE E 502.9**

**MINIMUM REQUIREMENTS FOR NON-FEDERALLY COVERED HVAC EQUIPMENT**

[ASHRAE 90.2: TABLE 6.9]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater source heat pump*</td>
<td>Cooling Mode</td>
<td>11.0 EER at 70°F Ent. Water</td>
<td>ARI 325</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.5 EER at 50°F Ent. Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating Mode</td>
<td>3.4 COP at 70°F Ent. Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0 COP at 50°F Ent. Water</td>
<td></td>
</tr>
<tr>
<td>Unitary A/C</td>
<td>Water cooled split system</td>
<td>9.3 EER at 85°F Ent. Water</td>
<td>ARI 210/240</td>
</tr>
<tr>
<td></td>
<td>Evaporatively cooled split system</td>
<td>8.3 IPLV at 75°F Ent. Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.3 EER at 95°F Out. Amb.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.5 IPLV at 80°F Out. Amb.</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8

* Performance for electrically powered equipment with capacity less than 65 000 Btu/h (19 kW) where rated in accordance with ARI 325.
E 503.1.1 New Buildings. Mechanical equipment and systems serving the heating, cooling, ventilating, or refrigeration needs of new buildings shall be in accordance with the requirements of this section as described in Section E 503.2. [ASHRAE 90.1:6.1.1.1]

E 503.1.2 Additions to Existing Buildings. Mechanical equipment and systems serving the heating, cooling, ventilating, or refrigeration needs of additions to existing buildings shall be in accordance with the requirements of this section as described in Section E 503.2. [ASHRAE 90.1:6.1.1.1.2]

E 503.1.3 Alterations to Heating, Ventilating, Air-Conditioning, and Refrigeration in Existing Buildings. New HVACR equipment as a direct replacement of existing HVACR equipment shall be in accordance with the following sections as applicable for the equipment being replaced:

1. Section E 503.3
2. Section E 503.4
3. Section E 503.4.6
4. Section E 503.4.6.2
5. Section E 503.4.6.3
6. Section E 503.4.6.4
7. Section E 503.4.6.8
8. Section E 503.4.6.9
9. Section E 503.4.6.11
10. Section E 503.5.1
11. Section E 503.5.3
12. Section E 503.5.3.1
13. Section E 503.5.6.1.2
14. Section E 503.5.6.2
15. Section E 503.5.6.5
16. Section E 503.5.7
17. Section E 503.5.7.2
18. Section E 503.5.8.1. [ASHRAE 90.1:6.1.1.3.1]

E 503.1.3.4 Piping. New and replacement piping shall comply with Section E 503.4.7.1.

Exceptions:

1. For equipment that is being modified or repaired but not replaced, provided that such modifications or repairs will not result in an increase in the annual energy consumption of the equipment using the same energy type.
2. Where a replacement or alteration of equipment requires extensive revisions to other systems, equipment, or elements of a building, and such replaced or altered equipment is a like-for-like replacement.
3. For a refrigerant change of existing equipment.
4. For the relocation of existing equipment.
5. For ducts and piping where there is insufficient space or access to comply with these requirements. [ASHRAE 90.1:6.1.1.3.5]

E 503.2 Compliance Path(s). Section E 503.0 shall be achieved in accordance with the requirements of Section E 503.1.1 through Section E 503.1.3.4, Section E 503.6, Section E 503.7, and one of the following:

1. Section E 503.3 and Section E 503.3.1
2. Section E 503.4
3. Section E 503.4 and Section E 503.8 [ASHRAE 90.1:6.2.1]

E 503.2.1 Projects Using Energy Cost Budget Method. Projects using the energy cost budget method in accordance with ASHRAE 90.1 shall comply with Section E 503.4, the mandatory provisions of this section, as a portion of that compliance path. [ASHRAE 90.1:6.2.2]

E 503.3 Simplified Approach Option for HVAC Systems. The simplified approach shall be an optional path for compliance where the following conditions are met:

1. The building is not more than two stories in height.
2. Gross floor area is less than 25 000 square feet (2322.6 m²).
3. The HVAC system in the building is in accordance with the requirements listed in Section E 503.3.1. [ASHRAE 90.1:6.3.1]

E 503.3.1 Criteria. The HVAC system shall comply with the following criteria:

1. The system serves a single HVAC zone.
2. The equipment shall comply with the variable flow requirements of Section E 503.5.6.2.
3. Cooling (where any) shall be provided by a unitary packaged or split-system air conditioner that is either air-cooled or evaporatively cooled, with efficiency that is in accordance with the requirements shown in Table E 503.7.1(1), Table E 503.7.1(2), or Table E 503.7.1(4) for the applicable equipment category.
4. The system shall have an air economizer in accordance with Section E 503.5 and Section E 503.4.6.13.
(5) Heating (where any) shall be provided by a unitary packaged or split-system heat pump that is in accordance with the applicable efficiency requirements shown in Table E 503.7.1(2) or Table E 503.7.1(4), a fuel-fired furnace that is in accordance with the applicable efficiency requirements shown in Table E 503.7.1(5), an electric resistance heater, or a baseboard system connected to a boiler that is in accordance with the applicable efficiency requirements shown in Table E 503.7.1(6).

(6) The system shall comply with the exhaust air energy recovery requirements in accordance with Section E 503.5.10.

(7) The system shall be controlled by a manual changeover or dual setpoint thermostat.

(8) Where a heat pump equipped with auxiliary internal electric resistance heaters is installed, controls shall be provided that prevent supplemental heater operation where the heating load is capable of being met by the heat pump alone during both steady-state operation and setback recovery. Supplemental heater operation shall be permitted during outdoor coil defrost cycles. The heat pump shall be controlled in accordance with one of the following:
   (a) A digital or electronic thermostat designed for heat pump use that energizes auxiliary heat where the heat pump has insufficient capacity to maintain setpoint or to warm up the space at a sufficient rate.
   (b) A multistage space thermostat and an outdoor air thermostat wired to energize auxiliary heat on the last stage of the space thermostat and where outdoor air temperature is less than 40°F (4°C).

Exceptions: Heat Pumps that comply with the following:

(1) Have a minimum efficiency regulated by NAEC.

(2) In accordance with the requirements shown in Table E 503.7.1(2).

(3) Include all usage of internal electric resistance heating.

(9) The system controls shall not permit reheat or other form of simultaneous heating and cooling for humidity control.

(10) Systems serving spaces other than hotel or motel guest rooms, and other than those requiring continuous operation, which have both a cooling or heating capacity more than 15 000 Btu/h (4.4 kW) and a supply fan motor power more than 0.75 horsepower (hp) (0.56 kW), shall be provided with a time clock that is in accordance with the following:
   (a) Can start and stop the system under different schedules for seven different day-types per week.
   (b) Is capable of retaining programming and time setting during a loss of power for a period of not less than 10 hours.

(c) Includes an accessible manual override that allows temporary operation of the system for up to 2 hours.

(d) Is capable of and configured with temperature setback down to 55°F (13°C) during off hours.

(e) Is capable of and configured with temperature setup to 90°F (32°C) during off hours.

(11) Systems serving hotel/motel guest rooms shall comply with Section E 503.4.6.3.5.

(12) Except for piping within manufacturer's units, HVAC piping shall be insulated in accordance with Table E 503.7.3(1) and Table E 503.7.3(2). Insulation exposed to weather shall be suitable for outdoor service, e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation.

(13) Ductwork and plenums shall be insulated in accordance with Table E 503.7.2 and shall be sealed in accordance with Section E 503.4.7.2.

(14) Construction documents shall require a ducted system to be air balanced in accordance with industry-accepted procedures.

(15) Outdoor air intake and exhaust systems shall comply with Section E 503.4.6.4 through Section E 503.4.6.5.

(16) Where separate heating and cooling equipment serves the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

(17) Systems with a design supply air capacity more than 10 000 ft³/min (4.7195 m³/s) shall have optimum start controls.

(18) The system shall comply with the demand control ventilation requirements of Section E 503.4.6.9 and the ventilation design requirements of Section E 503.5.6.6.

(19) The system shall comply with the door switch requirements of Section E 503.5.14. [ASHRAE 90.1:6.3.2]

E 503.3.2 Climate Zone Determination. Climate zones identified in this appendix shall be determined in accordance with ASHRAE 90.1. For locations in the United States and its territories, the assigned climate zone and, where required, the assigned climate zone letter shall be in accordance with ASHRAE 169.

Exception: Where recorded historical climatic data are available for a construction site, it is permitted to be used to determine compliance where approved by the Authority Having Jurisdiction. [ASHRAE 90.1:5.1.4.1]

E 503.4 Mandatory Provisions. Equipment shown in Table E 503.7.1(1) through Table E 503.7.1(16) shall have a minimum performance at the specified rating conditions where tested in accordance with the specified test procedure. Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy the stated...
requirements unless otherwise exempted by footnotes in the table. Equipment covered under the Federal Energy Policy Act of 1992 (EPACT) shall have no minimum efficiency requirements for operation at minimum capacity or other than standard rating conditions. Equipment used to provide service water-heating functions as part of a combination system shall satisfy the stated requirements for the appropriate space heating or cooling category.

Tables are as follows:

1. Table E 503.7.1(1), “Electrically Operated Unitary Air Conditioners and Condensing Units-Minimum Efficiency Requirements”
3. Table E 503.7.1 (3), “Water-Chilling Packages-Efficiency Requirements” (See Section E 503.4.1 for water-cooled centrifugal water-chilling packages that are designed to operate at nonstandard conditions.)
6. Table E 503.7.1 (6), “Gas- and Oil-Fired Boilers-Minimum Efficiency Requirements”
7. Table E 503.7.1 (7), “Performance Requirements for Heat-Rejection Equipment”
8. Table E 503.7.1 (8), “Heat Transfer Equipment”
11. Table E 503.7.1 (11), “Air Conditioners and Condensing Units Serving Computer Rooms”
12. Table E 503.7.1 (12), “Commercial Refrigerators and Freezers-Minimum Efficiency Requirements”
14. Table E 503.7.1 (14), “Vapor-Compression-Based Indoor Pool Dehumidifiers-Minimum Efficiency Requirements”

All furnaces with input ratings of 225 000 Btu/h (66 kW) or more, including electric furnaces, that are not located

within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating. Air conditioners primarily serving computer rooms and covered by ASHRAE 127 shall comply with the requirements in Table E 503.7.1(11). All other air conditioners shall meet the requirements in Table E 503.7.1(1). [ASHRAE 90.1:6.4.1.1]

E 503.4.1 Water-Cooled Centrifugal Chilling Packages. Equipment not designed for operation in accordance with AHRI 550/590 test conditions of 44.00°F (6.67°C) leaving and 54.00°F (12.22°C) entering chilled-fluid temperatures, and 2.4 gallons per minute per ton (gpm/ton) (0.00015 L/s/kg) evaporator fluid flow and with 85.00°F (29.44°C) entering and 94.30°F (34.61°C) leaving condenser-fluid temperatures, with 7.0 gpm/ton (0.00018 L/s/kg) condenser-fluid flow shall have maximum full-load kW/ton (FL) and part-load rating requirements adjusted in accordance with Equation E 503.4.1(1) through Equation E 503.4.1(3):

\[
\begin{align*}
FL_{adj} &= FL/K_{adj} \\
PLV_{adj} &= IPV/\text{IP}_{adj} \\
K_{adj} &= A \times B
\end{align*}
\]

Where:

| FL | full-load kW/ton value from Table E 503.7.1(3) |
| FL_{adj} | maximum full-load kW/ton rating, adjusted for nonstandard conditions |
| PLV_{adj} | maximum NPLV rating, adjusted for nonstandard conditions |
| A | \[0.00000014592 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.930273\] |
| B | 0.0015 \times LvgEvap + 0.934 |
| LIFT | \[LvgCond - LvgEvap\] |
| LvgEvap | Full-load evaporator leaving fluid temperature (°F) |

The \[FL_{adj}\] and \[PLV_{adj}\] values shall only be applicable for centrifugal chillers in accordance with meeting all of the following full-load design ranges:

1. Minimum Evaporator Leaving Temperature: 36.00°F (2.22°C) \[\leq LvgEvap \leq 60.00°F (15.56°C)\]
2. Maximum Condenser Leaving Temperature: 115°F (46.11°C) \[LvgCond \leq 115.00°F (46.11°C)\]
3. \[LIFT\] is not less than 20.00°F (-6.67°C) and not more than 80.00°F (26.67°C)

Manufacturers shall calculate the \[FL_{adj}\] and \[PLV_{adj}\] before determining whether to label the chiller in accordance with Section E 503.4.4. Chillers that are in accordance with ASHRAE 90.1 shall be labeled on chillers in accordance with the scope of ASHRAE 90.1.

Centrifugal chillers designed to operate outside of these ranges shall not be covered under this appendix.
Example: Path A, 600 ton (600 000 kg) centrifugal chiller Table E 503.7.1(3) efficiencies.

\[
\begin{align*}
F &= 0.5600 \text{ kW/ton} \\
IPLV &= 0.5000 \text{ kW/ton} \\
L_{\text{Evap}} &= 91.16^\circ\text{F} \\
L_{\text{Cond}} &= 91.16^\circ\text{F} \\
LIFT &= 91.16^\circ\text{F} - 42.00^\circ\text{F} = 49.16^\circ\text{F} \\
K_{adj} &= \frac{A \times B}{1.0228} \\
A &= 0.00000014592 \times (49.16)^4 + 0.00314196 \times (49.16)^2 - 0.147199 \times (49.16) + 3.93073 = 0.003281 \times 0.99700 \\
B &= 0.0015 \times 42.00 + 0.934 = 0.99700 \\
K_{adj} &= A \times B \\
F &_{adj} = 0.5600/(1.0228 \times 0.9970) = 0.549 \\
0.5600/1.02024 &= 0.5489 \text{ kW/ton} \\
PLV_{adj} &= 0.5000/(1.02024) = 0.4991 \text{ kW/ton} \\
&[\text{ASHRAE 90.1:6.4.1.2.1}]
\end{align*}
\]

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW, 1 gallon per minute = 0.06 L/s, °C = (°F-32)/1.8

**E 503.4.1.1 Positive Displacement (air- and water-cooled) Chilling Packages.** Equipment with an evaporator leaving fluid temperature higher than 32.00°F (0.00°C) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature less than below 115.00°F (46.11°C) shall be in accordance with compliance with Table E 503.7.1(3) when when tested or certified with water at standard rating conditions, in accordance with the referenced test procedure. [ASHRAE 90.1:6.4.1.2.2]

**E 503.4.2 Equipment not Listed.** Equipment not listed in the tables referenced in Section E 503.4 and Section E 503.4.1 shall be permitted to be used. [ASHRAE 90.1:6.4.1.3]

**E 503.4.3 Verification of Equipment Efficiencies.** Equipment efficiency information supplied by manufacturers shall be verified in accordance with one of the following:

1. Equipment covered under EPACT shall be in accordance with U.S. Department of Energy certification requirements.
2. Where a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program.
3. Where a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.
4. Where no certification program exists for a covered product, the equipment efficiency ratings shall be supported by data furnished by the manufacturer.
5. Where components such as indoor or outdoor coils from different manufacturers are used, the system designer shall specify component efficiencies whose combined efficiency is in accordance with the minimum equipment efficiency requirements in Section E 503.4 through Section E 503.4.4.1.
6. Requirements for plate-type liquid-to-liquid heat exchangers are listed in Table E 503.7.1(8). [ASHRAE 90.1:6.4.1.4]

**E 503.4.4 Labeling.** Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment is in accordance with the requirements of ASHRAE 90.1. [ASHRAE 90.1:6.4.1.5.1]

**E 503.4.4.1 Packaged Terminal Air Conditioners.** Nonstandard-size packaged air conditioners and heat pumps with existing sleeves having an external wall opening of less than 16 inches (406 mm) high or less than 42 inches (1067 mm) wide and having a cross-sectional area less than 670 square inches (406 mm) shall be factory labeled in accordance with the following:

- Manufactured for nonstandard-size applications only: n Not to be installed in new construction projects. [ASHRAE 90.1:6.4.1.5.2]

**E 503.4.5 Load Calculations.** Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with ASHRAE/ACCA 183. [ASHRAE 90.1:6.4.2.1]

**E 503.4.5.1 Pump Head.** Pump differential pressure (head) for the purpose of sizing pumps shall be determined in accordance with generally accepted engineering standards and handbooks acceptable to the Authority Having Jurisdiction. The pressure drop through each device and pipe segment in the critical circuit at design conditions shall be calculated. [ASHRAE 90.1:6.4.2.2]

**E 503.4.6 Zone Thermostatic Controls.** The supply of heating and cooling energy to each zone shall be individually controlled by thermostatic controls responding to temperature within the zone. For the purposes of Section E 503.4.6, a dwelling unit shall be permitted to be considered a single zone.

**Exceptions:** Independent perimeter systems that are designed to offset only building envelope loads shall be permitted to serve one or more zones also served by an interior system, provided that:

1. the perimeter system includes not less than one thermostatic control zone for each building exposure having walls facing only one orientation for 50 contiguous feet (15 240 mm) or more and
2. the perimeter system heating and cooling supply is controlled by thermostatic controls located within the zones served by the system.
Exterior walls and semiexterior walls are considered to have different orientations where the exposures they face differ by more than 45 degrees (0.79 rad). [ASHRAE 90.1:6.4.3.1.1]

E 503.4.6.1 Dead Band. Where used to control both heating and cooling, zone thermostatic controls shall be capable of and configured to provide a temperature range or dead band of not less than 5°F (3°C) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

Exceptions:
(1) Thermostats that require manual changeover between heating and cooling modes.
(2) Special occupancy or special applications where wide temperature ranges are not acceptable (such as retirement homes, process applications, museums, some areas of hospitals) and are approved by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.1.2]

E 503.4.6.2 Setpoint Overlap Restriction. Where heating and cooling to a zone are controlled by separate zone thermostatic controls located within the zone, means (such as limit switches, mechanical stops, or, for DDC systems, software programming) shall be provided to prevent the heating setpoint from exceeding the cooling setpoint minus any applicable proportional band. [ASHRAE 90.1:6.4.3.2]

E 503.4.6.3 Off-Hour Controls. HVAC systems shall have the off-hour controls required by Section E 503.4.6.3.1 through Section E 503.4.6.3.4.

Exceptions:
(1) HVAC systems intended to operate continuously.
(2) HVAC systems having a design heating capacity and cooling capacity less than 15,000 Btu/h (4.4 kW) that are equipped with readily accessible manual ON/OFF controls. [ASHRAE 90.1:6.4.3.3]

E 503.4.6.3.1 Automatic Shutdown. HVAC systems shall be equipped with not less than one of the following:
(1) Controls that can start and stop the system under different time schedules for seven different day-types per week, are capable of retaining programming and time setting during loss of power for a period of not less than 10 hours, and include an accessible manual override, or equivalent function, that allows temporary operation of the system for up to 2 hours.
(2) An occupant sensor that is capable of shutting the system off where no occupant is sensed for a period of up to 30 minutes.
(3) A manually operated timer capable of being adjusted to operate the system for up to 2 hours.
(4) An interlock to a security system that shuts the system off where the security system is activated.

Exception: Residential occupancies shall be permitted to use controls that can start and stop the system under two different time schedules per week. [ASHRAE 90.1:6.4.3.3.1]

E 503.4.6.3.2 Setback Controls. Heating systems shall be equipped with controls capable of and configured to automatically restart and temporarily operate the system as required to maintain zone temperatures above an adjustable heating setpoint of not less than 10°F (6°C) below the occupied heating setpoint. Cooling systems shall be equipped with controls capable of and configured to automatically restart and temporarily operate the mechanical cooling system as required to maintain zone temperatures below an adjustable cooling setpoint of not less than 5°F (3°C) above the occupied cooling setpoint or to prevent high space humidity levels.

Exception: Radiant heating systems capable of and configured with a setback heating setpoint at not less than 4°F (2°C) below the occupied heating setpoint. [ASHRAE 90.1:6.4.3.3.2]

E 503.4.6.3.3 Optimum Start Controls. Individual heating and cooling systems with setback controls and DDC shall have optimum start controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint, the outdoor temperature, and the amount of time prior to scheduled occupancy. Mass radiant floor slab systems shall incorporate floor temperature into the optimum start algorithm. [ASHRAE 90.1:6.4.3.3.3]

E 503.4.6.3.4 Zone Isolation. HVAC systems serving zones that are intended to operate or be occupied nonsimultaneously shall be divided into isolation areas. Zones shall be permitted to be grouped into a single isolation area provided it does not exceed 20 000 square feet (2322.6 m²) of conditioned floor area and does not include more than one floor. Each isolation area shall be equipped with isolation devices capable of and configured to automatically shut off the supply of conditioned air and outdoor air to and exhaust air from the area. Each isolation area shall be controlled independently by a device meeting the requirements of Section E 503.4.6.3.1. For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for any length of time while serving only the smallest isolation area served by the system or plant.

Exceptions: Isolation devices and controls are not required for the following:
(1) Exhaust air and outdoor air connections to isolation zones where the fan system to which they connect is not more than 5000 ft³/min (2.3597 m³/s).

(2) Exhaust airflow from a single isolation zone of less than 10 percent of the design airflow of the exhaust system to which it connects.

(3) Zones intended to operate continuously or intended to be inoperative only when all other zones are inoperative. [ASHRAE 90.1:6.4.3.3.4]

**E 503.4.6.3.5 Automatic Control of HVAC in Hotel/Motel Guest Rooms.** Hotels and motels with more than 50 guest rooms shall be provided with automatic controls for the HVAC equipment serving each guest room capable of and configured according to the requirements in Section E 503.4.6.3.1. [ASHRAE 90.1:6.4.3.3.5]

**E 503.4.6.3.5.1 Guest Room HVAC Set-Point Control.** Within 30 minutes of all occupants leaving the guest room, HVAC set points shall be automatically raised by not less than 4°F (2°C) from the occupant set point in the cooling mode and automatically lowered by at least 4°F (2°C) from the occupant set point in the heating mode. When the guest room is unrented and unoccupied, HVAC set points shall be automatically reset to 80°F (27°C) or higher in the cooling mode and to 60°F (16°C) or lower in the heating mode. Unrented and unoccupied guest rooms shall be determined by either of the following:

(1) The guest room has been continuously unoccupied for up to 16 hours.

(2) A networked guest room control system indicates the guest room is unrented and the guest room is unoccupied for no more than 30 minutes.

**Exceptions:**

(1) A networked guest room control system shall be permitted to return the thermostat set points to their default occupied set points 60 minutes prior to the time the room is scheduled to be occupied.

(2) Cooling for humidity control shall be permitted during unoccupied periods.

**E 503.4.6.4 Ventilation System Controls.** Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of and configured to automatically close during normal building operation and are interlocked to open as required by fire and smoke detection systems. [ASHRAE 90.1:6.4.3.4.1]

**E 503.4.6.4.1 Shutoff Damper Controls.** Outdoor air intake and exhaust systems shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use. Ventilation outdoor air and exhaust or relief dampers shall be capable of and configured to automatically shut off during preoccupancy building warm-up, cooldown, and setback, except when ventilation reduces energy costs or when ventilation shall be supplied to comply with the code requirements.

**Exceptions:**

(1) Back-draft gravity (nonmotorized) dampers shall be permitted for exhaust and relief in buildings less than three stories in height and for ventilation air intakes and exhaust and relief dampers in buildings of any height located in Climate Zones 0, 1, 2 and 3. Back-draft dampers for ventilation air intakes shall be protected from direct exposure to wind.

**TABLE E 503.4.6.4.2**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>VENTILATION AIR INTAKE</th>
<th>EXHAUST/RELIEF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NONMOTORIZED*</td>
<td>MOTORIZED</td>
</tr>
<tr>
<td>0, 1, 2</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>any height</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>not allowed</td>
<td>10</td>
</tr>
<tr>
<td>any height</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>4, 5b, 5c</td>
<td>not allowed</td>
<td>10</td>
</tr>
<tr>
<td>less than 3 stories</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>3 or more stories</td>
<td>not allowed</td>
<td>10</td>
</tr>
<tr>
<td>5a, 6, 7, 8</td>
<td>not allowed</td>
<td>4</td>
</tr>
<tr>
<td>less than 3 stories</td>
<td>not allowed</td>
<td>4</td>
</tr>
<tr>
<td>3 or more stories</td>
<td>not allowed</td>
<td>4</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 square foot = 0.0929 m², 1 inch water gauge = 0.249 kPa

* Dampers smaller than 24 inches (610 mm) in either dimension shall be permitted to have leakage of 40 ft³/min per square foot [0.203 (m³/s)/m²].
(2) Back-draft gravity (nonmotorized) dampers shall be permitted in systems with a design outdoor air intake or exhaust capacity of 300 ft³/min (0.142 m³/s) or less.

(3) Dampers shall not be required in ventilation or exhaust systems serving unconditioned spaces.

(4) Dampers shall not be required in exhaust systems serving Type 1 kitchen exhaust hoods. [ASHRAE 90.1:6.4.3.4.2]

**E 503.4.6.4.2 Dampers Leakage.** Where outdoor air supply, and exhaust or relief dampers are required in Section E 503.4.6.4, they shall have a maximum leakage rate in accordance with Table E 503.4.6.4.2 where tested in accordance with AMCA 500D. [ASHRAE 90.1:6.4.3.4.3]

**E 503.4.6.4.3 Ventilation Fan Controls.** Fans with motors more than 0.75 hp (0.56 kW) shall have automatic controls in accordance with Section E 503.4.6.3.1 that are capable of and configured to shut off fans when not required.

**Exception:** HVAC systems intended to operate continuously. [ASHRAE 90.1:6.4.3.4.4]

**E 503.4.6.5 Enclosed Parking Garage Ventilation.** Enclosed parking garage ventilation systems shall automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50 percent or less of design capacity, provided acceptable contaminant levels are maintained.

**Exceptions:**
(1) Garages not more than 30 000 square feet (2787.09 m²) with ventilation systems that do not utilize mechanical cooling or mechanical heating.

(2) Garages that have a garage area to ventilation system motor nameplate hp/horsepower ratio that exceeds 1500 square feet per horsepower (ft²/hp) (186.8 m²/kW) and do not utilize mechanical cooling or mechanical heating.

(3) Where not permitted by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.4.5]

**E 503.4.6.6 Heat Pump Auxiliary Heat Control.** Heat pumps equipped with internal electric resistance heaters shall have controls that prevent supplemental heater operation where the heating load is capable of being met by the heat pump alone during both steady-state operation and setback recovery. Supplemental heater operation shall be permitted during outdoor coil defrost cycles.

**Exception:** Heat pumps whose minimum efficiency is regulated by U.S. National Appliance Energy Conservation Act (NAECA) and whose ratings are in accordance with the requirements shown in Table E 503.7.1(2) and includes the use of an internal electric resistance heating. [ASHRAE 90.1:6.4.3.5]

**E 503.4.6.7 Humidification and Dehumidification.** Humidity control shall prevent the use of fossil fuel or electricity to produce relative humidity (RH) more than above 30 percent in the warmest zone served by the humidification system and to reduce the relative humidity ratio to less than below 60 percent in the coldest zone served by the dehumidification system. Where a zone is served by a system or systems with both humidification and dehumidification capability, means (such as limit switches, mechanical stops, or, for DDC systems, software programming) shall be provided capable of preventing and configured to prevent simultaneous operation of humidification and dehumidification equipment.

**Exceptions:**
(1) Zones served by desiccant systems, used with direct evaporative cooling in series.

(2) Systems serving zones where specific humidity levels are required, such as museums and hospitals, and approved by the Authority Having Jurisdiction or required by accreditation standards and humidity controls are capable of and configured to maintain a dead band of not less than at least 10 percent relative humidity where no active humidification or dehumidification takes place.

(3) Systems serving zones where humidity levels are required to be maintained with precision of not more than ± 5 percent relative humidity to comply with applicable codes or accreditation standards or as approved by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.6]

**E 503.4.6.8 Freeze Protection and Snow or Ice Melting Systems.** Freeze protection systems, such as heat tracing of outdoor piping and heat exchangers, including self-regulating heat tracing, shall include automatic controls capable of and configured to shut off the systems when outdoor air temperatures are more than 40°F (4°C) or when the conditions of the protected fluid will prevent freezing. Snow and ice melting systems shall include automatic controls capable of and configured to shut off the systems when the pavement temperature is more than 50°F (10°C) and no precipitation is falling, and an automatic or manual control that will allow shutoff when the outdoor temperature is more than 40°F (4°C) so that the potential for snow or ice accumulation is negligible. [ASHRAE 90.1:6.4.3.7]

**E 503.4.6.9 Ventilation Controls for High-Occupancy Areas.** Demand control ventilation (DCV) shall be required for spaces that are more than 500 square feet (46.45 m²) and with a design occupancy for ventilation of not less than 25 people per 1000 square feet (92.9 m²) of floor area and served by systems with one or more of the following:
(1) Air-economizer.

(2) Automatic modulating control of outdoor air damper.

(3) Design outdoor airflow more than 3000 ft³/min (1.4158 m³/s).
Exceptions:

(1) Systems with exhaust air energy recovery in accordance with Section E 503.5.10.

(2) Multiple-zone systems without DDC of individual zones communicating with a central control panel.

(3) Systems with a design outdoor airflow less than 750 ft³/min (0.3540 m³/s).

(4) Spaces where more than 75 percent of the space design outdoor airflow is required for makeup air that is exhausted from the space or transfer air that is required for makeup air that is exhausted from other spaces.

(5) Spaces with one of the following occupancy categories in accordance with Chapter 4 or ASHRAE 62.1: correctional cells, daycare sickrooms, science labs, barbers, beauty and nail salons, and bowling alley seating. [ASHRAE 90.1:6.4.3.8]

E 503.4.6.10 Outdoor Heating. Radiant heat systems shall be used to provide heat outdoors. Outdoor radiant heating systems shall be provided with controls that sense the presence of occupants or other device that automatically shuts down the system where no occupants are in the heating area.

E 503.4.6.11 Heated or Cooled Vestibules. Heating for vestibules and for air curtains with integral heating shall include automatic controls capable of and configured to shut off the heating system when outdoor air temperatures are more than 45°F (7.2°C) Vestibule heating and cooling systems shall be controlled by a thermostat in the vestibule capable of and configured to limit heating to a maximum of 60°F (15.5°C) and cooling to a minimum of 85°F (29.4°C).

Exception: Heating or cooling provided by site-recovered energy or by transfer air that would otherwise be exhausted. [ASHRAE 90.1:6.4.3.9]

E 503.4.6.12 Direct Digital Control (DDC) Requirements. Direct digital control shall be required in accordance with Section E 503.4.6.12.1 through Section E 503.4.6.12.3. [ASHRAE 90.1:6.4.3.10]

E 503.4.6.12.1 DDC Applications. DDC shall be provided in the applications and qualifications in accordance with Table E 503.4.6.12.1.

Exception: DDC is not required for systems using the simplified approach to compliance in accordance with Section E 503.3. [ASHRAE 90.1:6.4.3.10.1]

E 503.4.6.12.2 DDC Controls. Where DDC is required by Section E 503.4.6.12.1, the DDC system shall be capable of and configured with all of the following, as required, to provide the control logic required in Section E 503.5:

1) Monitoring zone and system demand for fan pressure, pump pressure, heating, and cooling.

2) Transferring zone and system demand information from zones to air distribution system controllers and from air distribution systems to heating and cooling plant controllers.

TABLE E 503.4.6.12.1

<table>
<thead>
<tr>
<th>BUILDING STATUS</th>
<th>APPLICATION</th>
<th>QUALIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>New building</td>
<td>Air-handling system and all zones served by the system</td>
<td>Individual systems supplying more than three zones and with fan system bhp of 10 hp or more</td>
</tr>
<tr>
<td>New building</td>
<td>Chilled-water plant and all coils and terminal units served by the system</td>
<td>Individual plants supplying more than three zones and with design cooling capacity of 300 000 Btu/h or more</td>
</tr>
<tr>
<td>New building</td>
<td>Hot-water plant and all coils and terminal units served by the system</td>
<td>Individual plants supplying more than three zones and with design heating capacity of 300 000 Btu/h or more</td>
</tr>
<tr>
<td>Alteration or addition</td>
<td>Zone terminal unit such as VAV box</td>
<td>Where existing zones served by the same air-handling, chilled-water, or hot-water system have DDC</td>
</tr>
<tr>
<td>Alteration or addition</td>
<td>Air-handling system or fan coil</td>
<td>Where existing air-handling system(s) and fan-coil(s) served by the same chilled- or hot-water plant have DDC</td>
</tr>
<tr>
<td>Alteration or addition</td>
<td>New air-handling system and all new zones served by the system</td>
<td>Individual systems with fan system bhp of 10 hp or more and supplying more than three zones and more than 75 percent of zones are new</td>
</tr>
<tr>
<td>Alteration or addition</td>
<td>New or upgraded chilled-water plant</td>
<td>Where all chillers are new and plant design cooling capacity is 300 000 Btu/h or more</td>
</tr>
<tr>
<td>Alteration or addition</td>
<td>New or upgraded hot-water plant</td>
<td>Where all boilers are new and plant design heating capacity is 300 000 Btu/h or more</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units = 0.293 kW, 1 horsepower = 0.746 kW
(3) Automatically detecting those zones and systems that are capable of excessively driving the reset logic and generate an alarm or other indication to the system operator.

(4) Readily allowing operator removal of zone(s) from the reset algorithm. [ASHRAE 90.1:6.4.3.10.2]

E 503.4.6.12.3 DDC Display. Where DDC is required in accordance with Section E 503.4.6.12.1 for new buildings, the DDC system shall be capable of trending and graphically displaying input and output points. [ASHRAE 90.1:6.4.6.1.2]

E 503.4.6.13 Economizer Fault Detection Diagnostics (FDD). Air-cooled direct-expansion cooling units listed in Tables E 503.7.1(1) and E 503.7.1(2), where an air economizer is installed in accordance with Section E 503.5, shall include a fault detection and diagnostics (FDD) system complying with the following:

(1) The following temperature sensors shall be permanently installed to monitor system operation:
   (a) Outdoor air
   (b) Supply air
   (c) Return air, where required for economizer control

(2) The system shall have the capability of displaying the value of each sensor.

(3) The FDD system or unit controls shall be capable of and configured to provide system status by indicating the following:
   (a) Free cooling available
   (b) Economizer enabled
   (c) Compressor enabled
   (d) Heating enabled
   (e) Mixed-air low-limit cycle active

(4) The FDD system or unit controls shall have provisions to manually initiate each operating mode so that the operation of compressors, economizers, fans, and the heating system can be independently tested and verified.

(5) The FDD system shall be capable of and configured to detect the following faults:
   (a) Air temperature sensor failure/fault
   (b) Not economizing when the unit should be economizing
   (c) Economizing when the unit should not be economizing
   (d) Damper not modulating
   (e) Excess outdoor air

(6) The FDD system shall be capable of and configured to report faults to a fault management application or DDC system accessible by operating or service personnel, or annunciated locally on zone thermostats. [ASHRAE 90.1:6.4.3.12]

E 503.4.7 HVAC System Construction and Insulation. HVAC Ducts shall be constructed in accordance with provisions contained in the SMACNA HVAC Duct Construction Standard. HVAC system construction and insulation shall comply with Section E 503.4.7.1 and Section E 503.4.7.2.

E 503.4.7.1 Insulation. Insulation required by this section shall be installed in accordance with industry-accepted standards. These requirements shall not apply to HVAC equipment. Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance, and wind, but not limited to the following:

(1) Insulation exposed to weather shall be suitable for outdoor service (e.g., protected by aluminum, sheet metal, painted canvas, or plastic cover). Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that is capable of causing degradation of the material.

(2) Insulation covering chilled-water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space shall include a vapor retardant located outside the insulation (unless the insulation is inherently vapor retardant), penetrations and joints of which shall be sealed. [ASHRAE 90.1:6.4.4.1.1]

E 503.4.7.1.1 Duct and Plenum Insulation. Supply and return ducts and plenums installed as part of an HVAC air distribution system shall be thermally insulated in accordance with Table E 503.7.2.

Exceptions:

(1) Factory-installed plenums, casings, or ductwork furnished as a part of HVAC equipment tested and rated in accordance with Section E 503.4 through Section E 503.4.4.1.

(2) Ducts or plenums located in heated spaces, semi-heated spaces, or cooled spaces.

(3) For runouts less than 10 feet (3048 mm) in length to air terminals or air outlets, the rated R-value of insulation shall not be required to exceed R-3.5.

(4) Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas exceeding 5 square feet (0.5 m²) shall not be required to exceed R-2; those not exceeding 5 square feet (0.5 m²) shall not be required to be insulated. [ASHRAE 90.1:6.4.4.1.2]
E 503.4.7.1.2 Piping Insulation. Piping shall be thermally insulated in accordance with Table E 503.7.3(1) and Table E 503.7.3(2).

Exceptions:

(1) Factory-installed piping within HVAC equipment tested and rated in accordance with Section E 503.4 through Section E 503.4.4.1.

(2) Piping that conveys fluids having a design operating temperature range between 60°F (16°C) and 105°F (41°C), inclusive.

(3) Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electricity (such as roof and condensate drains, domestic cold water supply, and natural gas piping).

(4) Where heat gain or heat loss will not increase energy usage (such as liquid refrigerant piping).

(5) For piping 1 inch (25.4 mm) or less, insulation shall not be required for strainers, control valves, and balancing valves. [ASHRAE 90.1:6.4.4.1.3]

E 503.4.7.1.3 Sensible Heating Panel. Thermally ineffective panel surfaces of sensible heating panels, including U-bends and headers, shall be insulated with not less than a minimum of R-3.5. Adjacent building envelope insulation shall be applied to counts toward this insulation value requirement. [ASHRAE 90.1:6.4.4.1.4]

E 503.4.7.1.4 Radiant Floor Heating. The bottom surfaces of floor structures incorporating radiant heating shall be insulated not less than with a minimum of R-3.5. Adjacent building envelope insulation shall be applied to counts toward this insulated value requirement.

Exception: Heated slab-on-grade floors incorporating radiant heating shall be in accordance with ASHRAE 90.1. [ASHRAE 90.1:6.4.4.1.5]

E 503.4.7.2 Ductwork and Plenum Leakage. Transverse joints, longitudinal seams, and duct wall penetrations shall be sealed. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL 181A or UL 181B by an independent testing laboratory and the tape is used in accordance with that certification. All other connections shall be considered transverse joints, including but not limited to spin-ins, taps, other branch connections, access door frames and jambs, and duct connections to equipment.

Exceptions:

(1) Rods that penetrate the duct wall that shall be permitted to move in order to function properly (control rod for volume damper) shall not be sealed in a fashion that prevents them from working properly.

(2) Spiral lock seams in a round or flat oval duct.

E 503.4.7.2.1 Duct Leakage Tests. Ductwork shall be leak-tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual. Representative sections totaling not less than 20 percent of the total installed duct area shall be tested. Where the tested 20 percent fail to comply with the requirements of this section, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fail to comply with the requirements of this section, then 100 percent of the total installed duct area shall be tested. Sections shall be selected by the building owner or designated representative of the building owner. Positive pressure leakage testing shall be permitted for negative pressure ductwork. The permitted duct leakage shall be not more than the following:

\[ L_{max} = C_L P^{0.65} \]  

Where:

\[ L_{max} \] = maximum permitted leakage, \( \text{ft}^3/\text{min}/100 \text{ square feet} \) \( [(m^3/s)/m^2] \) duct surface area.

\[ C_L \] = Six, duct leakage class, \( \text{ft}^3/\text{min}/100 \text{ square feet} \) \( [(m^3/s)/m^2] \) duct surface area at 1 inch water column (0.2 kPa).

\[ P \] = test pressure, which shall be equal to the design duct pressure class rating, inch water column (kPa).

E 503.5 Prescriptive Path, Economizers. Cooling systems shall include either an air economizer or fluid economizer in accordance with Section E 503.5.1 through Section E 503.5.4.1.

Exceptions: Economizers shall not be required for the following systems:

(1) Individual fan-cooling units with a supply capacity less than the minimum listed in Table E 503.5(1).

(2) Chilled-water cooling systems without a fan or that use induced airflow, where the total capacity of these systems is less than 1 000 000 Btu/h (293 kW) in Climate Zones 0, 1B, and 2 through 4; less than 1 400 000 Btu/h (410 kW) in Climate Zones 5 through 8; or any size in Climate Zone 1A.

(3) Systems that include nonparticulate air treatment in accordance with ASHRAE 62.1.

(4) In hospitals and ambulatory surgery centers, where more than 75 percent of the air designed to be supplied by the system is to spaces that are required to be humidified more than 35°F (2°C) dew-point temperature to comply
with applicable codes or accreditation standards; in all other buildings, where more than 25 percent of the air designed to be supplied by the system is to spaces that are designed to be humidified more than 35°F (2°C) dew-point temperature to satisfy process needs. This exception shall not apply to computer rooms.

(5) Systems that include a condenser heat recovery system with a minimum capacity in accordance with Section E 503.5.10.1.2.

(6) Systems that serve residential spaces where the system capacity is less than five times the requirement listed in Table E 503.5(1).

(7) Systems that serve spaces whose sensible cooling load at design conditions, excluding transmission and infiltration loads, is less than or equal to transmission and infiltration losses at an outdoor temperature of 60°F (16°C).

(8) Systems expected to operate less than 20 hours per week.

(9) Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

(10) For comfort cooling where the cooling efficiency is not less than the efficiency improvement requirements in accordance with Table E 503.5(2).

(11) Systems primarily serving computer rooms where in accordance with one of the following:

(a) The total design cooling load of all computer rooms in the building is less than 3 000 000 Btu/h (879 kW) and the building in which they are located is not served by a centralized chilled water plant.

(b) The room total design cooling load is less than 600 000 Btu/h (176 kW) and the building in which they are located is served by a centralized chilled water plant.

(c) The local water authority does not permit cooling towers.

(d) Less than 600 000 Btu/h (176 kW) of computer room cooling equipment capacity is being added to an existing building.

(12) Dedicated systems for computer rooms where a minimum of 75 percent of the design load serves one of the following:

(a) Spaces classified as an essential facility.

(b) Spaces having a design of Tier IV in accordance with TIA 942.

(c) Spaces classified as Critical Operations Power Systems (COPS) in accordance with NFPA 70.

(d) Spaces where core clearing and settlement services are performed such that their failure to settle pending financial transactions is capable of systemic risk in accordance with “The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System” (April 7, 2003). [ASHRAE 90.1:6.5.1.1]

**APPENDIX E**

**TABLE E 503.5(1)**

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY WHERE AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A, 0B, 1A, 1B</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2A, 2B, 3A, 4A, 5A, 6A, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8</td>
<td>≥54 000 Btu/h</td>
</tr>
</tbody>
</table>

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

**TABLE E 503.5(2)**

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>EFFICIENCY IMPROVEMENT*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>17%</td>
</tr>
<tr>
<td>2B</td>
<td>21%</td>
</tr>
<tr>
<td>3A</td>
<td>27%</td>
</tr>
<tr>
<td>3B</td>
<td>32%</td>
</tr>
<tr>
<td>3C</td>
<td>65%</td>
</tr>
<tr>
<td>4A</td>
<td>42%</td>
</tr>
<tr>
<td>4B</td>
<td>49%</td>
</tr>
<tr>
<td>4C</td>
<td>64%</td>
</tr>
<tr>
<td>5A</td>
<td>49%</td>
</tr>
<tr>
<td>5B</td>
<td>59%</td>
</tr>
<tr>
<td>5C</td>
<td>74%</td>
</tr>
<tr>
<td>6A</td>
<td>56%</td>
</tr>
<tr>
<td>6B</td>
<td>65%</td>
</tr>
<tr>
<td>7</td>
<td>72%</td>
</tr>
<tr>
<td>8</td>
<td>77%</td>
</tr>
</tbody>
</table>

* Where a unit is rated with an IPLV, IEER or SEER, to eliminate the required economizer, the minimum cooling efficiency of the HVAC unit shall be increased by the percentage shown. Where the HVAC unit is rated with a full load metric like EER cooling, these shall be increased by the percentage shown.

**E 503.5.1 Air Economizers, Design Capacity.** Air economizer systems shall be capable of and configured to modulate outdoor air and return air dampers to provide up to 100 percent of the design supply air quantity as outdoor air for cooling. [ASHRAE 90.1:6.5.1.1.1]

**E 503.5.1.1 Control Signal.** Economizer controls shall be capable of and configured to sequence the dampers with the mechanical cooling equipment and shall not be controlled by only mixed air temperature.

**Exception:** The use of mixed air temperature limit control shall be permitted for systems controlled from space temperature (such as single-zone systems). [ASHRAE 90.1:6.5.1.1.2]

**E 503.5.1.2 High-Limit Shutoff.** Air economizers shall be capable of and configured to automatically reduce outdoor air intake to the design minimum outdoor air quantity where outdoor air intake will no longer reduce cooling energy use.
High-limit shutoff control types and associated setpoints for specific climate zones shall be chosen from Table E 503.5.1.2. [ASHRAE 90.1:6.5.1.1.3]

**E 503.5.1.3 Dampers.** Return air, exhaust or relief, and outdoor air dampers shall comply with Section E 503.4.6.4.2. [ASHRAE 90.1:6.5.1.1.4]

**E 503.5.1.4 Relief of Excess Outdoor Air.** Systems shall provide a means to relieve excess outdoor air during air economizer operation to prevent overpressurizing the building. The relief air outlet shall be located so as to avoid recirculation into the building. [ASHRAE 90.1:6.5.1.1.5]

**TABLE E 503.5.1.2**

**HIGH-LIMIT SHUTOFF CONTROL SETTINGS FOR AIR ECONOMIZERS**

**[ASHRAE 90.1: TABLE 6.5.1.1.3]**

<table>
<thead>
<tr>
<th>CONTROL TYPE</th>
<th>ALLOWS ONLY IN CLIMATE ZONE AT LISTED SETPOINT</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHERE):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EQUATION</td>
<td>DESCRIPTION</td>
</tr>
<tr>
<td>Fixed dry bulb temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0B, 1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8</td>
<td>$T_{oa} &gt; 75^\circ$F</td>
<td>Outdoor air temperature exceeds $75^\circ$F</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4A</td>
<td>$T_{oa} &gt; 70^\circ$F</td>
<td>Outdoor air temperature exceeds $70^\circ$F</td>
</tr>
<tr>
<td>Differential dry bulb temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0B, LB, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8</td>
<td>$T_{oa} &gt; T_{ra}$</td>
<td>Outdoor air temperature exceeds return air temperature</td>
</tr>
<tr>
<td>Fixed enthalpy with fixed dry-bulb temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>$h_{oa} &gt; 28 \text{ Btu/lb}^1$ or $T_{oa} &gt; 75^\circ$F</td>
<td>Outdoor air enthalpy exceeds $28 \text{ Btu/lb}^1$ of dry air or outdoor air temperature exceeds $75^\circ$F</td>
</tr>
<tr>
<td>Differential enthalpy with fixed dry-bulb temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>$h_{oa} &gt; h_{ra}$ or $T_{oa} &gt; 75^\circ$F</td>
<td>Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds $75^\circ$F</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8, 1 British thermal unit per pound = 2326 J/kg

Notes:
1 At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at $75^\circ$F (24°C) and 50 percent relative humidity. As an example, at approximately 6000 feet (1829 m) elevation, the fixed enthalpy limit shall be approximately 30.7 Btu/lb (71 408 J/kg).
2 Devices with selectable rather than adjustable setpoints shall be capable of being set to within 2°F (1°C) and 2 Btu/lb (4649 J/kg) of the setpoint listed.
APPENDIX E

(2) Enthalpy and the value of a differential enthalpy sensor shall be accurate to ±3 Btu/lb (7 E+03 J/kg) over the range of 20 Btu/lb (4.6 E+04 J/kg) to 36 Btu/lb (8.4 E+04 J/kg).

(3) Relative humidity shall be accurate to ±5 percent over the range of 20 percent to 80 percent relative humidity. [ASHRAE 90.1:6.5.1.1.6]

E 503.5.2 Fluid Economizers, Design Capacity. Fluid economizer systems shall be capable of providing up to 100 percent of the expected system cooling load at outdoor air temperatures of not more than 50°F (10°C) dry bulb or 45°F (7°C) wet bulb.

Exceptions:

(1) Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at the dry bulb and wet bulb temperatures in accordance with Table E 503.5.2 is met with water-cooled fluid economizers.

(2) Systems primarily serving computer rooms in which 100 percent of the expected system cooling load at the dry bulb temperatures listed in Table E 503.5.2 is met with air-cooled fluid economizers.

(3) Systems where dehumidification requirements are not capable of being met using outdoor air temperatures of 50°F (10°C) dry bulb or 45°F (7°C) wet bulb and where 100 percent of the expected system cooling load at 45°F (7°C) dry bulb or 40°F (4°C) wet bulb is met with water-cooled fluid economizers. [ASHRAE 90.1:6.5.1.2.1]

E 503.5.2.1 Maximum Hydronic Pressure Drop. Precooling coils and fluid-to-water heat exchangers used as part of a fluid economizer system shall either have a water-side pressure drop of less than 15 feet of water (45 kPa), or a secondary loop shall be created so that the coil or heat exchanger pressure drop is not seen by the circulating pumps where the system is in the normal cooling (non-economizer) mode. [ASHRAE 90.1:6.5.1.2.2]

E 503.5.3 Integrated Economizer Control. Economizer systems shall be integrated with the mechanical cooling system and be capable of and configured to provide partial cooling even where additional mechanical cooling is required to be in accordance with the remainder of the cooling load. Controls shall not false load the mechanical cooling systems by limiting or disabling the economizer or by other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

Units that include an air economizer shall comply with the following:

(1) Unit controls shall have the mechanical cooling capacity control interlocked with the air economizer controls such that the outdoor air damper is at the 100 percent open position when mechanical cooling is on, and the outdoor air damper does not begin to close to prevent coil freezing due to minimum compressor run time until the leaving air temperature is less than 45°F (7°C).

(2) DX units with a rated capacity no less than 65 000 Btu/h (18 kW) that control the capacity of the mechanical cooling directly based on occupied space temperature shall have not less than two stages of mechanical cooling capacity.

(3) Other DX units, including those that control space temperature by modulating the airflow to the space, shall comply with the requirements of Table E 503.5.3. [ASHRAE 90.1:6.5.1.3]

Table E 503.5.3

<table>
<thead>
<tr>
<th>RATING CAPACITY, Btu/h</th>
<th>MINIMUM NUMBER OF MECHANICAL COOLING STAGES</th>
<th>MINIMUM COMPRESSOR DISPLACEMENT*</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥65 000 and &lt;240 000</td>
<td>3</td>
<td>≤35% of full load</td>
</tr>
<tr>
<td>≥240 000</td>
<td>4</td>
<td>≤25% full load</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units = 0.293 kW

* For mechanical cooling stage control that does not use variable compressor displacement the percent displacement shall be equivalent to the mechanical cooling capacity reduction evaluated at the full load rating conditions for the compressor.

E 503.5.4 Economizer Heating System Impact. HVAC system design and economizer controls shall be such that economizer operation does not increase the building heating energy use during normal operation.

Exception: Economizers on variable air valve (VAV) systems that cause zone level heating to increase due to a reduction in supply air temperature. [ASHRAE 90.1:6.5.1.4]

E 503.5.4.1 Economizer Humidification System Impact. Systems with hydronic cooling and humidification systems designed to maintain inside humidity at a dew-point temperature more than 35°F (2°C) shall use a fluid economizer where an economizer is required in accordance with Section E 503.5 through Section E 503.5.4.1. [ASHRAE 90.1:6.5.1.5]

E 503.5.5 Simultaneous Heating and Cooling Limitation, Zone Controls. Zone thermostatic controls shall prevent the following:

(1) Reheating.

(2) Recooling.

(3) Mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems.

(4) Other simultaneous operation of heating and cooling systems to the same zone.
Exceptions:

(1) Zones for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:

(a) Twenty percent of the zone design peak supply for systems with DDC and 30 percent for other systems.

(b) The outdoor airflow rate required to be in accordance with the ventilation requirements of Chapter 4 or ASHRAE 62.1 for the zone.

(c) Any higher rate that is capable of demonstrating can be demonstrated, to the satisfaction of the Authority Having Jurisdiction, to reduce overall system annual energy use by offsetting reheat or recool energy losses through a reduction in outdoor air intake for the system.

(d) The airflow rate required to be in accordance with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.

(2) Zones with DDC that comply with the following:

(a) The airflow rate in dead band between heating and cooling does not exceed the larger of the following:

(1) Twenty percent of the zone design peak supply rate.

(2) The outdoor airflow rate required to be in accordance with the ventilation requirements of Chapter 4 or ASHRAE 62.1 for the zone.

(3) A higher rate that is capable of demonstrating can be demonstrated, to the satisfaction of the Authority Having Jurisdiction, to reduce overall system annual energy use by offsetting reheat or recool energy losses through a reduction in outdoor air intake.

(b) The airflow rate required in accordance with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates.

(3) Laboratory exhaust systems in accordance that comply with Section E 503.5.11.3.

(4) Zones where not less than at least 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from site-recovered energy (including condenser heat) or site-solar energy source. [ASHRAE 90.1:6.5.2.1]

E 503.5.5.1 Supply Air Temperature Reheat Limit. Where reheating is permitted in accordance with this appendix, zones that have both supply and return or exhaust air openings more than 6 feet (1829 mm) above the floor shall not supply heating air more than 20°F (11°C) above the space temperature setpoint.

Exceptions:

(1) Laboratory exhaust systems in accordance with Section E 503.5.11.3.

(2) During preoccupancy building warm-up and setback. [ASHRAE 90.1:6.5.2.1.1]

E 503.5.5.2 Hydronic System Controls. The heating of fluids in hydronic systems that have been previously mechanically cooled and the cooling of fluids that have been previously mechanically heated shall be limited in accordance with Section E 503.5.5.2.1 through Section E 503.5.5.2.3. [ASHRAE 90.1:6.5.2.2]

E 503.5.5.2.1 Three-Pipe System. Hydronic systems that use a common return system for both hot water and chilled water shall not be used. [ASHRAE 90.1:6.5.2.2.1]

E 503.5.5.2.2 Two-Pipe Changeover System. Systems that use a common distribution system to supply both heated and chilled water are acceptable where in accordance with the following:

(1) The system is designed to allow a dead band between changeover from one mode to the other of not less than 15°F (8°C) outdoor air temperature.

(2) The system is designed to operate and is provided with controls that will allow operation in one mode for not less than 4 hours before changing over to the other mode.

(3) Reset controls are provided that allow heating and cooling supply temperatures at the changeover point to be not more than 30°F (17°C) apart. [ASHRAE 90.1:6.5.2.2.2]

E 503.5.5.2.3 Hydronic (Water Loop) Heat Pump Systems. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection (e.g., cooling tower) and heat addition (e.g., boiler) shall have the following:

(1) Controls that are capable of and configured to provide a heat pump water supply tem-
perature dead band of not less than at least 20°F (11°C) between initiation of heat rejection and heat addition by the central devices (e.g., tower and boiler).

(2) For climate zone 3 through zone 8, where a closed-circuit cooling tower (fluid cooler) is used, either an automatic valve shall be installed to bypass all but a minimal flow of water around the tower (for freeze protection) or low-leakage positive closure dampers shall be provided. Where an open-circuit cooling tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass all heat pump water flow around the tower. Where an open-circuit cooling tower is used in conjunction with a separate heat exchanger to isolate the tower from the heat pump loop, then heat loss shall be controlled by shutting down the circulation pump on the cooling tower loop.

Exception: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, dead bands of less than 20°F (11°C) shall be permitted. [ASHRAE 90.1:6.5.2.2.3]

E 503.5.5.3 Dehumidification. Where humidity controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams; or other means of simultaneous heating and cooling of the same airstream.

Exceptions:
(1) The system is capable of and configured to reduce supply air volume to 50 percent or less of the design airflow rate or the minimum outdoor air ventilation rate in accordance with ASHRAE 62.1 or other applicable federal, state, or local code or recognized standard, whichever is larger before simultaneous heating and cooling takes place.

(2) The individual fan cooling unit has a design cooling capacity of not more than 65 000 Btu/h (19 kW) and is capable of and configured to unload to 50 percent capacity before simultaneous heating and cooling takes place.

(3) The individual mechanical cooling unit has a design cooling capacity of not more than 40 000 Btu/h (11.7 kW). An individual mechanical cooling unit is a single system composed of a fan or fans and a cooling coil capable of providing mechanical cooling.

(4) Systems serving spaces where specific humidity levels are required to satisfy process needs, such as vivariums, museums, surgical suites, pharmacies, and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses, and ice arenas, and where the building includes site-recovered energy or site-solar energy that provide energy equal to 75 percent of the annual energy for reheating or for providing warm air in mixing systems. This exception shall not apply to computer rooms.

(5) Not less than 90 percent of the annual energy for reheating or for providing warm air in mixing systems is provided from site-recovered energy (including condenser heat) or site-solar energy.

(6) Systems where the heat added to the airstream is the result of the use of a desiccant system and 75 percent of the heat added by the desiccant system is removed by a heat exchanger, either before or after the desiccant system with energy recovery. [ASHRAE 90.1:6.5.2.3]

E 503.5.5.4 Humidifier Preheat. Humidifiers with preheating jackets mounted in the airstream shall be provided with an automatic valve to shut off preheat where humidification is not required. [ASHRAE 90.1:6.5.2.4.1]

E 503.5.5.4.1 Insulation. Humidification system dispersion tube hot surfaces in the

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### TABLE E 503.5.6.1(1)

**FAN POWER LIMITATION**

[ASHRAE 90.1: TABLE 6.5.3.1-1]

<table>
<thead>
<tr>
<th>LIMIT</th>
<th>CONSTANT VOLUME</th>
<th>VARIABLE VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Fan system motor nameplate (hp)</td>
<td>Allowable nameplate motor (hp)</td>
<td>( hp \leq CFM_S \times 0.0011 )</td>
</tr>
<tr>
<td>Option 2: Fan system (bhp)</td>
<td>Allowable fan system (bhp)</td>
<td>( bhp \leq CFM_S \times 0.00094 + A )</td>
</tr>
</tbody>
</table>

*Where:*
- \( CFM_S \) = the maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute (m³/s)
- \( hp \) = the maximum combined motor nameplate horsepower (kW)
- \( bhp \) = the maximum combined fan brake horsepower (kW)
- \( A = \text{sum of} (PD \times CFM_D / 4131) \)
- \( PD \) = each applicable pressure drop adjustment from Table E 503.5.6.1(2) in inch water column (kPa)
- \( CFM_D \) = the design airflow through each applicable device from Table E 503.5.6.1(2) in cubic feet per minute (m³/s)

For SI units: 1 horsepower = 0.746 kW, 1 cubic foot per minute = 0.00047 m³/s
airstreams of ducts or air-handling units shall be insulated with a product with an insulating value of not less than R-0.5.

**Exception:** Systems where mechanical cooling, including economizer operation, does not occur simultaneously with humidification. [ASHRAE 90.1:6.5.2.4.2]

**E 503.5.5.5 Preheat Coils.** Preheat coils shall have controls that stop their heat output where mechanical cooling, including economizer operation, is occurring. [ASHRAE 90.1:6.5.2.5]

**E 503.5.6 Air System Design and Control.** HVAC air system design and control shall be in accordance with the provisions of Section E 503.5.6.1 through Section E 503.5.6.6.

**E 503.5.6.1 Fan System Power and Efficiency.** Each HVAC system having a total fan system motor nameplate horsepower (kW) exceeding 5 hp (3.7 kW) at fan system design conditions shall not exceed the allowable fan system motor nameplate horsepower (kW) (Option 1) or fan system brake horsepower (kW) (Option 2) as shown in Table E 503.5.6.1(1). This shall include supply fans, return or relief fans, exhaust fans, and fan-powered terminal units associated with systems providing heating or cooling capability that operate at fan system design conditions. Single-zone VAV systems shall comply with the constant-volume fan power limitation.

**Exceptions:**

1. Hospital, vivarium, and laboratory systems that utilize flow control devices on exhaust, return, or both to maintain space pressure relationships necessary for occupant health and safety, or environmental control shall be permitted to use variable-volume fan power limitation.

2. Individual exhaust fans with motor nameplate horsepower of 1 hp (0.7 kW) or less. [ASHRAE 90.1:6.5.3.1.1]

**E 503.5.6.1.1 Motor Nameplate Horsepower.** For each fan, the selected fan motor shall be no larger than the first available motor size more greater than the brake horsepower (bhp) (kW). The fan brake horsepower (bhp) shall be indicated on the design documents to allow for compliance verification by the Authority Having Jurisdiction.

**Exceptions:**

1. For fans less than 6 bhp (4.5 kW), where the first available motor larger than the bhp (kW) has a nameplate rating within 50 percent of the bhp (kW), the next larger nameplate motor size shall be permitted to be selected.

2. For fans 6 bhp (4.5 kW) and larger, where the first available motor larger than the bhp (kW) has a nameplate rating within 30 percent of the bhp (kW), the next larger name-

### TABLE E 503.5.6.1(2)

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms</td>
<td>0.5 in. w.c. (2.15 in w.c. for laboratory and vivarium systems)</td>
</tr>
<tr>
<td>Return, exhaust, or both airflow control devices</td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td>Exhaust filters, scrubbers, or other exhaust treatment</td>
<td>The pressure drop of device calculated at fan system design condition</td>
</tr>
<tr>
<td>Particulate Filtration Credit: MERV 9 through 12</td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td>Particulate Filtration Credit: MERV 13 through 15</td>
<td>0.9 in. w.c.</td>
</tr>
<tr>
<td>Particulate Filtration Credit: MERV 16 and greater, and electronically enhanced filters</td>
<td>Pressure drop calculated at 2x clean filter pressure drop at fan system design condition</td>
</tr>
<tr>
<td>Carbon and other gas-phase air cleaners</td>
<td>Clean filter pressure drop at fan system design condition</td>
</tr>
<tr>
<td>Biosafety cabinet</td>
<td>Pressure drop of device at fan system design condition</td>
</tr>
<tr>
<td>Energy recovery device, other than coil runaround loop</td>
<td>For each airstream [(2.2 x enthalpy recovery ratio) - 0.5] in w.c.</td>
</tr>
<tr>
<td>Coil runaround loop</td>
<td>0.6 in. w.c. for each airstream</td>
</tr>
<tr>
<td>Evaporative humidifier or cooler in series with another cooling coil</td>
<td>Pressure drop of device at fan system design condition</td>
</tr>
<tr>
<td>Sound attenuation section (fans serving spaces with design background noise goals below NC35)</td>
<td>0.15 in. w.c.</td>
</tr>
<tr>
<td>Exhaust system serving fume hoods</td>
<td>0.35 in. w.c.</td>
</tr>
<tr>
<td>Laboratory and vivarium exhaust systems in high-rise buildings</td>
<td>0.25 in. w.c. per 100 feet of vertical duct exceeding 75 ft</td>
</tr>
</tbody>
</table>

**DEDUCTIONS**

- Systems without central cooling device: -0.6 in. w.c.
- Systems without central heating device: -0.3 in. w.c.
- Systems with central electric resistance heat: -0.2 in. w.c.
plate motor size shall be permitted to be selected.

(3) Systems that are in accordance with Section E 503.5.6.1, Option 1.

(4) Fans with motor nameplate horsepower of less than 1 hp (0.7 kW). [ASHRAE 90.1:6.5.3.1.2]

**E 503.5.6.1.2 Fan Efficiency.** Fans shall have a fan efficiency grade (FEG) of 67 or more, based on manufacturers' certified data in accordance with AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

**Exceptions:**

(1) Individual fans with a motor nameplate horsepower of 5 hp (3.7 kW) or less that are not part of a group operated as the functional equivalent of a single fan.

(2) Multiple fans in series or parallel (e.g., fan arrays) that have a combined motor nameplate horsepower of 5 hp (3.7 kW) or less and are operated as the functional equivalent of a single fan.

(3) Fans that are part of equipment listed under Section E 503.4.

(4) Fans included in equipment bearing a third party-certified seal for air or energy performance of the equipment package.

(5) Powered wall/roof ventilators (PRV).

(6) Fans outside the scope of AMCA 205.

(7) Fans that are intended to only operate during emergency conditions. [ASHRAE 90.1:6.5.3.2.1]

**E 503.5.6.2 Supply Fan Airflow Control.** Each cooling systems listed in Table E 503.5.6.2 shall be designed to vary the indoor supply fan airflow as a function of load and shall comply with the following requirements:

(1) DX and chilled-water cooling units that control the capacity of the mechanical cooling directly based on space temperature shall have a minimum of two stages of fan control. Low or minimum speed shall not exceed 66 percent of full speed. At low or minimum speed, the fan system shall draw not more than 40 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.

(2) All other units, including DX cooling units and chilled-water units that control the space temperature by modulating the airflow to the space, shall have modulating fan control. Minimum speed shall not exceed 50 percent of full speed. At minimum speed, the fan system shall draw not more than 30 percent of the power at full fan speed. Low or minimum speed shall be used during periods of low cooling load and ventilation-only operation.

(3) Units that include an air-side economizer to comply with the requirements of Section E 503.5 through Section E 503.5.4.1 shall have not less than a minimum of two speeds of fan control during economizer operation.

**Exceptions:**

(1) Modulating fan control shall not be required for chilled-water and evaporative cooling units with less than 1 hp (0.7 kW) fan motors where the units are not used to provide ventilation air and where the indoor fan cycles with the load.

(2) Where the volume of outdoor air required to comply with the ventilation requirements of Chapter 4 or ASHRAE 62.1 at low speed exceeds the air that would be delivered at the speed defined in Section E 503.5.6.2(1), or Section E 503.5.6.2(2), then the minimum speed shall be selected to provide the required ventilation air. [ASHRAE 90.1:6.5.3.2.2]

**TABLE E 503.5.6.2 FAN AIRFLOW CONTROL**

<table>
<thead>
<tr>
<th>COOLING SYSTEM TYPE</th>
<th>FAN MOTOR SIZE, (hp)</th>
<th>MECHANICAL COOLING CAPACITY, (Btu/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DX cooling</td>
<td>Any</td>
<td>≥65,000</td>
</tr>
<tr>
<td>Chilled-water and evaporative cooling</td>
<td>≥1/4</td>
<td>Any</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 horsepower = 0.746 kW, 1 cubic foot per minute = 0.00047 m³/s

**E 503.5.6.2.1 VAV Static Pressure Sensor Location.** Static pressure sensors used to control VAV fans shall be located such that the controller setpoint is not more than 1.2 inches water column (0.30 kPa). Where this results in the sensor being located downstream of major duct splits, sensors shall be installed in each major branch to ensure that static pressure is maintained in each.

**Exception:** Systems that are in accordance with Section E 503.5.6.2.2. [ASHRAE 90.1:6.5.3.2.2]

**E 503.5.6.2.2 VAV Setpoint Reset.** For multiple-zone VAV systems having a total fan system motor nameplate horsepower exceeding 5 hp (3.7 kW) with DDC of individual zones reporting to the central control panel, static pressure setpoint shall be reset based on the zone requiring the most pressure, such as the setpoint is reset lower until one zone damper is nearly wide open. Controls shall provide the following:
(1) Monitor zone damper positions or other indicator of need for static pressure.

(2) Automatically detect those zones that are capable of excessively driving the reset logic and generate an alarm to the system operator.

(3) Readily allow operator removal of zones from the reset algorithm. [ASHRAE 90.1:6.5.3.2.3]

E 503.5.6.3 Multiple-Zone VAV System Ventilation Optimization Control. Multiple-zone VAV systems with DDC of individual zone boxes reporting to a central control panel shall include means to automatically reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency in accordance with ASHRAE 62.1, Section 404.0.

Exceptions:
(1) VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units.

(2) Systems where total design exhaust airflow is more than 70 percent of total design outdoor air intake flow requirements. [ASHRAE 90.1:6.5.3.3]

E 503.5.6.4 Supply Air Temperature Reset Controls. Multiple zone HVAC systems shall include controls that automatically reset the supply air temperature in response to representative building loads, or to outdoor air temperature. The controls shall reset the supply air temperature to not less than 25 percent of the difference between the

### TABLE E 503.5.6.5(1)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR POLYPHASE SMALL ELECTRIC MOTORS*
[ASHRAE 90.1: TABLE 10.8-3]

<table>
<thead>
<tr>
<th>NUMBER OF POLES</th>
<th>OPEN MOTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNCHRONOUS SPEED (RPM)</td>
<td>2</td>
</tr>
<tr>
<td>MOTOR HORSEPOWER</td>
<td>3600</td>
</tr>
<tr>
<td>0.25</td>
<td>65.6</td>
</tr>
<tr>
<td>0.33</td>
<td>69.5</td>
</tr>
<tr>
<td>0.50</td>
<td>73.4</td>
</tr>
<tr>
<td>0.75</td>
<td>76.8</td>
</tr>
<tr>
<td>1</td>
<td>77.0</td>
</tr>
<tr>
<td>1.5</td>
<td>84.0</td>
</tr>
<tr>
<td>2</td>
<td>85.5</td>
</tr>
<tr>
<td>3</td>
<td>85.5</td>
</tr>
</tbody>
</table>

* Average full-load efficiencies shall be established in accordance with 10 CFR 431.

### TABLE E 503.5.6.5(2)
MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS*
[ASHRAE 90.1: TABLE 10.8-4]

<table>
<thead>
<tr>
<th>NUMBER OF POLES</th>
<th>OPEN MOTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYNCHRONOUS SPEED (RPM)</td>
<td>2</td>
</tr>
<tr>
<td>MOTOR HORSEPOWER</td>
<td>3600</td>
</tr>
<tr>
<td>0.25</td>
<td>66.6</td>
</tr>
<tr>
<td>0.33</td>
<td>70.5</td>
</tr>
<tr>
<td>0.50</td>
<td>72.4</td>
</tr>
<tr>
<td>0.75</td>
<td>76.2</td>
</tr>
<tr>
<td>1</td>
<td>80.4</td>
</tr>
<tr>
<td>1.5</td>
<td>81.5</td>
</tr>
<tr>
<td>2</td>
<td>82.9</td>
</tr>
<tr>
<td>3</td>
<td>84.1</td>
</tr>
</tbody>
</table>

* Average full-load efficiencies shall be established in accordance with 10 CFR 431.
design supply air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity shall be permitted. Zones that are expected to experience relatively constant loads, such as electronic equipment rooms, shall be designed for the fully reset supply temperature.

Exceptions:

(1) Climate zones 0A, 1A, 2A, and 3A.

(2) Systems that prevent reheating, recooling, or mixing of heated and cooled supply air.

(3) Systems where not less than 75 percent of the energy for reheating or site-solar energy or energy from site recovered energy or site-solar energy is from site recovered energy or site-solar energy. [ASHRAE 90.1:6.5.3.5]

E 503.5.6.5 Fractional Horsepower Fan Motors. Motors for fans that are 1/12 hp (62.1 W) or more and less than 1 hp (0.7 kW) shall be electronically-commutated motors or shall have a motor efficiency of not less than 70 percent where rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans shall be permitted to use sheave adjustments for airflow balancing in lieu of a varying motor speed.

Exceptions:

(1) Motors in the airstream within fan coils and terminal units that operate when providing heating to the space served.

(2) Motors installed in space conditioning equipment certified in accordance with Section E 503.4 through Section E 503.4.4.1.

(3) Motors shown in Table E 503.5.6.5(1) or Table E 503.5.6.5(2). [ASHRAE 90.1:6.5.3.6]

E 503.5.6.6 Ventilation Design. The required minimum outdoor air rate is the larger of the minimum outdoor air rate or the minimum exhaust air rate required by ASHRAE 62.1, ASHRAE 170, or applicable codes or accreditation standards. Outdoor air ventilation systems shall comply with one of the following:

(1) Design minimum system outdoor air provided shall not exceed 135 percent of the required minimum outdoor air rate.

(2) Dampers, ductwork, and controls shall be provided that allow the system to supply no more than the required minimum outdoor air rate with a single setpoint adjustment.

(3) The system includes exhaust air energy recovery complying with Section E 503.5.10. [ASHRAE 90.1:6.5.3.7]

E 503.5.7 Hydronic System Design and Control. Boiler systems with design input of 1 000 000 Btu/h (293 kW) or more shall comply with the turndown ratio in accordance with Table E 503.5.7.

The system turndown requirement shall use multiple single-input boilers, one or more modulating boilers, or a combination of single-input and modulating boilers.

Boilers shall comply with the minimum efficiency requirements in Table E 503.7.1(6). [ASHRAE 90.1:6.5.4.1]

<table>
<thead>
<tr>
<th>BOILER SYSTEM DESIGN INPUT, Btu/h</th>
<th>MINIMUM TURNDOWN RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥1 000 000 and ≤5 000 000</td>
<td>3 to 1</td>
</tr>
<tr>
<td>&gt;5 000 000 and ≤10 000 000</td>
<td>4 to 1</td>
</tr>
<tr>
<td>&gt;10 000 000</td>
<td>5 to 1</td>
</tr>
</tbody>
</table>

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

E 503.5.7.1 Hydronic Variable Flow Systems. Chilled- and hot-water distribution systems that include three or more control valves designed to modulate or step open and close as a function of load shall be designed for variable fluid flow and shall be capable of and configured to reduce pump flow rates to not more than the larger of 25 percent of the design flow rate or the minimum flow required by the heating/cooling equipment manufacturer for the proper operation of equipment. Individual or parallel pumps serving fan-flowing hot-water or chilled-water systems, where the nameplate horsepower of the motor or combined parallel motors is not less than the power shown in Table E 503.5.7.1, shall have controls or devices that will result in pump motor demand of not more than 30 percent of design wattage at 50 percent of design water flow. The controls or devices shall be controlled as a function of desired flow or to maintain a minimum required differential pressure. Differential pressure shall be measured at or near the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure. The differential pressure setpoint shall not exceed 110 percent of that required to achieve design flow through the heat exchanger. Where differential pressure control is used to comply with this section, and DDC systems are used, the setpoint shall be reset downward based on valve positions until one valve is nearly wide open.

Exceptions:

(1) Differential pressure set-point reset is not required where valve position is used to comply with Section E 503.5.7.3.

(2) Variable-pump flow control is not required on heating-water pumps where more than 50 percent of annual heat is generated by an electric boiler.

(3) Variable flow is not required for primary pumps in a primary/secondary system.

(4) Variable flow is not required for a coil pump provided for freeze protection.

(5) Variable flow is not required for heat recovery coil runaround loops. [ASHRAE 90.1:6.5.4.2]
E 503.5.7.2 Chiller and Boiler Isolation. Where a chilled-water plant includes more than one chiller, provisions shall be made so that the fluid flow through the chiller is automatically shut off where the chiller is shut down. Chillers piped in series for the purpose of increased temperature differential, shall be considered as one chiller. Where constant-speed chilled-water or condenser water pumps are used to serve multiple chillers, the number of pumps shall be not less than the number of chillers and staged on and off with the chillers. [ASHRAE 90.1:6.5.4.3.1]

E 503.5.7.2.1 Boiler Isolation. Where a boiler plant includes more than one boiler, provisions shall be made so that the fluid flow through the boiler is automatically shut off where the boiler is shut down. Where constant-speed hot-water pumps are used to serve multiple boilers, the number of pumps shall be not less than the number of boilers and staged on and off with the boilers. [ASHRAE 90.1:6.5.4.3.1]

E 503.5.7.3 Chilled- and Hot-Water Temperature Reset Controls. Chilled- and hot-water systems with a design capacity exceeding 300 000 Btu/h (88 kW) supplying chilled or heated water (or both) to comfort conditioning systems shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature. Where DDC is used to control valves, the set point shall be reset based on valve positions until one valve is nearly wide open or setpoint limits of the system equipment or application have been reached.

Exceptions:
(1) Where chilled-water supply is already cold, such as chilled water supplied from a district cooling or thermal energy storage system, such that blending would be required to achieve the reset chilled-water supply temperature.
(2) Where a specific temperature is required for a process.
(3) Water temperature reset is not required where valve position is used to comply with Section E 503.5.7. [ASHRAE 90.1:6.5.4.4]

E 503.5.7.4 Hydronic (Water Loop) Heat Pump and Water-Cooled Unitary Air Conditioners. Hydronic heat pumps and water-cooled unitary air-conditioners shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off. Exception: Units employing water economizers. [ASHRAE 90.1:6.5.4.5.1]

E 503.5.7.4.1 Controls. Hydronic heat pumps and water-cooled unitary air-conditioners having a total pump system power exceeding 5 hp (3.7 kW) shall have controls, devices, or both (such as variable speed control) that will result in the appropriate flow rate at the outlet of the device.

---

**TABLE E 503.5.7.1**

<table>
<thead>
<tr>
<th>CHILLED WATER PUMPS</th>
<th>HEATING WATER PUMPS</th>
<th>MOTOR NAMEPLATE HORSEPOWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN THESE CLIMATE ZONES</td>
<td>IN THESE CLIMATE ZONES</td>
<td></td>
</tr>
<tr>
<td>0A, 0B, 1A, 1B, 2B</td>
<td>NR</td>
<td>≥2 hp</td>
</tr>
<tr>
<td>2A, 3B</td>
<td>NR</td>
<td>≥3 hp</td>
</tr>
<tr>
<td>3A, 3C, 4A, 4B</td>
<td>7, 8</td>
<td>≥5 hp</td>
</tr>
<tr>
<td>4C, 5A, 5B, 5C, 6A, 6B</td>
<td>3C, 5A, 5C, 6A, 6B</td>
<td>≥7.5 hp</td>
</tr>
<tr>
<td>-</td>
<td>4A, 4C, 5B</td>
<td>≥10 hp</td>
</tr>
<tr>
<td>7, 8</td>
<td>4B</td>
<td>≥15 hp</td>
</tr>
<tr>
<td>-</td>
<td>2A, 2B, 3A, 3B</td>
<td>≥25 hp</td>
</tr>
<tr>
<td>-</td>
<td>1B</td>
<td>≥100 hp</td>
</tr>
<tr>
<td>-</td>
<td>0A, 0B, 1A</td>
<td>≥200 hp</td>
</tr>
</tbody>
</table>

For SI units: 1 horsepower = 0.746 kW

---

**TABLE E 503.5.7.5**

<table>
<thead>
<tr>
<th>OPERATING HOURS/YEAR</th>
<th>≤2000 HOURS/YEAR</th>
<th>&gt;2000 AND ≤4400 HOURS/YEAR</th>
<th>&gt;4400 HOURS/YEAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL PIPE SIZE, (inches)</td>
<td>OTHER</td>
<td>VARIABLE FLOW/ VARIABLE SPEED</td>
<td>OTHER</td>
</tr>
<tr>
<td>2 1⁄2</td>
<td>120</td>
<td>180</td>
<td>85</td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>270</td>
<td>140</td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>530</td>
<td>260</td>
</tr>
<tr>
<td>5</td>
<td>410</td>
<td>620</td>
<td>310</td>
</tr>
<tr>
<td>6</td>
<td>740</td>
<td>1100</td>
<td>570</td>
</tr>
<tr>
<td>8</td>
<td>1200</td>
<td>1800</td>
<td>900</td>
</tr>
<tr>
<td>10</td>
<td>1800</td>
<td>2700</td>
<td>1300</td>
</tr>
<tr>
<td>12</td>
<td>2500</td>
<td>3800</td>
<td>1900</td>
</tr>
<tr>
<td>Maximum velocity for pipes over 14-24 inches in size</td>
<td>8.5 ft/s</td>
<td>13.0 ft/s</td>
<td>6.5 ft/s</td>
</tr>
</tbody>
</table>

For SI units: 1 gallon per minute = 0.06 L/s, 1 foot per second = 0.3048 m/s, 1 inch = 25.4 mm
in pump motor demand of not more than 30 percent of design wattage at 50 percent of design water flow. [ASHRAE 90.1:6.5.4.5.2]

E 503.5.7.5 Pipe Sizing. Chilled-water and condenser-water piping shall be sized such that the design flow rate in each piping segment does not exceed the values listed in Table E 503.5.7.5 for the appropriate total annual hours of operation. Piping size selections for systems that operate under variable flow conditions, such as (e.g., modulating two-way control valves at coils) and that contain variable-speed pump motors shall be permitted to be made from the “Variable Flow/Variable Speed” columns. All others shall be made from the “Other” columns.

Exceptions:

1. Design flow rates exceeding the values in Table E 503.5.7.5 shall be permitted in specific sections of pipe where the pipe piping if the piping in question is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during more than 30 percent or more of operating hours.

2. Piping systems that have not more than the equivalent or less total pressure drop than the same system constructed with standard weight steel pipe with piping and fittings sized in accordance with Table E 503.5.7.5. [ASHRAE 90.1:6.5.4.6]

E 503.5.8 Heat Rejection Equipment. Section E 503.5.8 through Section E 503.5.9 apply to heat-rejection equipment used in comfort cooling systems, such as air-cooled condensers, dry coolers, open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers.

Exception: Heat-rejection devices whose energy usage is included in the equipment efficiency ratings listed in Table E 503.7.1(1) through Table E 503.7.1(4). [ASHRAE 90.1:6.5.5.1]

E 503.5.8.1 Fan Speed Control. The fan system on a heat-rejection device powered by an individual motor or an array of motors with a connected power, including the motor service factor, totalizing 5 hp (3.7 kW) or more shall have controls and/or devices (such as variable-speed control) that shall result in fan motor demand of no more than 30 percent of design wattage at 50 percent of the design airflow and that shall automatically change the fan speed to control the leaving fluid temperature or condensing temperature pressure of the heat-rejection device.

Exceptions:

1. Condenser fans serving multiple refrigerant circuits or fluid cooling circuits.

2. Condenser fans serving flooded condensers. [ASHRAE 90.1:6.5.5.2.1]

E 503.5.8.2 Variable-Speed Fan Drives. Multicell heat rejection equipment with variable-speed fan drives shall:

1. Operate the maximum number of fans allowed that comply with the manufacturer’s requirements for all system components.

2. Control all fans to the same fan speed required for the instantaneous cooling duty, as opposed to staged (on/off) operation. Minimum fan speed shall comply with the minimum allowable speed of the fan drive system per the manufacturer’s recommendations. [ASHRAE 90.1:6.5.5.2.2]

E 503.5.9 Limitation on Centrifugal Fan Open-Circuit Cooling Towers. Centrifugal fan open-circuit cooling towers with a combined rated capacity of 1100 gallons per minute (gpm) (69.39 L/s) or greater at 95°F (35°C) condenser water return, 85°F (29°C) condenser water supply, and 75°F (24°C) outdoor air wet-bulb temperature shall comply with the energy efficiency requirement for axial fan open-circuit cooling towers in accordance with Table E 503.7.1(7).

Exception: Centrifugal open-circuit cooling towers that are ducted (inlet or discharge) or require external sound attenuation. [ASHRAE 90.1:6.5.5.3]

E 503.5.9.1 Tower Flow Turndown. Open-circuit cooling towers used on water-cooled chiller systems that are configured with multiple- or variable-speed condenser water pumps shall be designed so that all open-circuit cooling tower cells can be run in parallel with the larger of the following:

1. The flow that is produced by the smallest pump at its minimum expected flow rate.

2. Fifty percent of the design flow for the cell. [ASHRAE 90.1:6.5.5.4]

E 503.5.10 Exhaust Air Energy Recovery. Each fan system shall have an energy recovery system where the design supply fan airflow rate exceeds the value listed in Table E 503.5.10(1) and Table E 503.5.10(2), based on the climate zone and percentage of outdoor air at design airflow conditions. Table E 503.5.10(1) shall be used for all ventilation systems that operate less than 8000 hours per year and Table E 503.5.10(2) shall be used for all ventilation systems that operate 8000 or more hours per year.

Energy recovery systems required by this section shall result in an enthalpy recovery ratio of not less than 50 percent. A fifty percent enthalpy recovery ratio shall mean a change in the enthalpy of the outdoor air supply equal to 50 percent of the difference between the outdoor air and entering exhaust air enthalpies at design conditions. Provision shall be provided to bypass or control the energy recovery system to permit air economizer operation in accordance with Section E 503.5.1.

Exceptions:

1. Laboratory systems that are in accordance with Section E 503.5.11.3.

2. Systems serving spaces that are not cooled and that are heated to less than 60°F (16°C).
Where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy or site-solar energy.

Heating energy recovery in Climate Zones 0, 1, and 2.

Cooling energy recovery in climate zones 3C, 4C, 5B, 5C, 6B, 7, and 8.

Where the sum of the airflow rates exhausted and relieved within 20 feet (6096 mm) of each other is less than 75 percent of the design outdoor airflow rate, excluding exhaust air that is:

(a) used for another energy recovery system,
(b) not allowed by ASHRAE 170 for use in energy recovery systems with leakage potential, or
(c) of Class 4 as defined in ASHRAE 62.1.

Systems requiring dehumidification that employ energy recovery in series with the cooling coil.

Systems expected to operate less than 20 hours per week at the outdoor air percentage in accordance with Table E 503.5.10(1). [ASHRAE 90.1:6.5.6.1]

### Table E 503.5.10(1)

**Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Less Than 8000 Hours Per Year**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>≥10% and &lt;20%</th>
<th>≥20% and &lt;30%</th>
<th>≥30% and &lt;40%</th>
<th>≥40% and &lt;50%</th>
<th>≥50% and &lt;60%</th>
<th>≥60% and &lt;70%</th>
<th>≥70% and &lt;80%</th>
<th>≥80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3B, 3C, 4B, 4C, 5B</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>0B, 1B, 2B, 5C</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>≥26 000</td>
<td>≥12 000</td>
<td>≥5000</td>
<td>≥4000</td>
</tr>
<tr>
<td>6B</td>
<td>≥28 000</td>
<td>≥26 500</td>
<td>≥11 000</td>
<td>≥5500</td>
<td>≥4500</td>
<td>≥3500</td>
<td>≥2500</td>
<td>≥1500</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥26 000</td>
<td>≥16 000</td>
<td>≥5500</td>
<td>≥4500</td>
<td>≥3500</td>
<td>≥2000</td>
<td>≥1000</td>
<td>≥120</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥4500</td>
<td>≥4000</td>
<td>≥2500</td>
<td>≥1000</td>
<td>≥140</td>
<td>≥120</td>
<td>≥100</td>
<td>≥80</td>
</tr>
</tbody>
</table>

Design supply fan airflow rate (cubic feet per minute)

For SI units: 1 cubic foot per minute = 0.00047 m³/s

* NR = Not Required

### Table E 503.5.10(2)

**Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Not Less Than 8000 Hours Per Year**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>≥10% and &lt;20%</th>
<th>≥20% and &lt;30%</th>
<th>≥30% and &lt;40%</th>
<th>≥40% and &lt;50%</th>
<th>≥50% and &lt;60%</th>
<th>≥60% and &lt;70%</th>
<th>≥70% and &lt;80%</th>
<th>≥80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>0B, 1B, 2B, 3B, 4C, 5C</td>
<td>NR</td>
<td>≥19 500</td>
<td>≥9000</td>
<td>≥5000</td>
<td>≥4000</td>
<td>≥3000</td>
<td>≥1500</td>
<td>≥120</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4A, 5A, 6B</td>
<td>≥2500</td>
<td>≥2000</td>
<td>≥1000</td>
<td>≥500</td>
<td>≥140</td>
<td>≥120</td>
<td>≥100</td>
<td>≥80</td>
</tr>
<tr>
<td>4A, 5A, 6A, 6B, 7, 8</td>
<td>≥200</td>
<td>≥130</td>
<td>≥100</td>
<td>≥80</td>
<td>≥70</td>
<td>≥60</td>
<td>≥50</td>
<td>≥40</td>
</tr>
</tbody>
</table>

Design supply fan airflow rate (cubic feet per minute)

For SI units: 1 cubic foot per minute = 0.00047 m³/s

* NR = Not Required

E 503.5.10.1 Condenser Heat Recovery Systems. Condenser heat recovery systems shall be installed for the heating or preheating of service hot water where the following conditions exist:

1. The facility operates 24 hours a day.
2. The total installed heat rejection capacity of the water-cooled system is more than 6 000 000 Btu/h (1757 kW) of heat rejection.
3. The design service water heating load is more than 1 000 000 Btu/h (293 kW). [ASHRAE 90.1:6.5.6.2.1]

E 503.5.10.1.2 Capacity. The required heat recovery system shall have the capacity to provide the smaller of:

1. Sixty percent of the peak heat-rejection load at design conditions or
2. Preheat of the peak service hot-water draw to 85°F (29°C).

Exceptions:

1. Facilities that employ condenser heat recovery for space heating with a heat recovery design of more than exceeding 30
percent of the peak water-cooled condenser load at design conditions.

(2) Facilities that provide 60 percent of their service water heating from site-solar energy, or site-recovered energy, or from other sources. [ASHRAE 90.1:6.5.6.2.2]

E 503.5.11 Exhaust Systems. Exhaust systems shall comply with Section E 503.5.11.1 through Section E 503.5.11.3.

E 503.5.11.1.1503.5.11.1 Conditioned Supply Air Transfer Air. Conditioned supply air delivered to a space with a kitchen hood mechanical exhaust shall not exceed the greater of the following:

1. The supply flow required to be in accordance with the space heating or cooling load.
2. The ventilation rate required by the Authority Having Jurisdiction, the Facility Environmental and Safety department, or ASHRAE 62.1; or
3. The hood mechanical exhaust flow minus the available transfer air from adjacent conditioned spaces, or return air plenums on the same floor, not in different smoke or fire compartments, and that at their closest point are within 15 feet (4572 mm) of each other. Available transfer air is that portion of outdoor ventilation air that:
   a. is not required to satisfy other exhaust needs, such as restrooms; and
   b. is not required to maintain pressurization of adjacent other spaces; and
   c. is transferable according to applicable codes and standards and to the class of air recirculation limitations in ASHRAE 62.1.

Exceptions:
1. Biosafety level classified laboratories 3 or higher.
2. Vivarium spaces.
3. Spaces that are required by applicable codes and standards to be maintained at positive pressure relative to adjacent spaces. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.

(4) Spaces where the demand for transfer air may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy. [ASHRAE 90.1:6.5.7.1.2]

E 503.5.11.2 Kitchen Exhaust Systems. Replacement air introduced directly into the hood cavity of kitchen exhaust hoods shall not exceed 10 percent of the hood exhaust airflow rate. [ASHRAE 90.1:6.5.7.2.1]

E 503.5.11.2.1 Exhaust Flow Rate. Where a kitchen or dining facility has a total kitchen hood exhaust airflow rate exceeding 5000 ft³/min (2.3597 m³/s), each hood shall have an exhaust rate in accordance with Table E 503.5.11.2. Where a single hood, or hood section, is installed over appliances with different duty ratings, the maximum allowable flow rate for the hood or hood section shall not exceed the values in Table E 503.5.11.2 for the highest appliance duty rating under the hood or hood section. Refer to ASHRAE 154 for definitions of hood type, appliance duty, and net exhaust flow rate.

Exception: Seventy-five percent or more of the total replacement air is transfer air that would otherwise be exhausted. [ASHRAE 90.1:6.5.7.2.2]

E 503.5.11.2.2 Kitchen or Dining Facility. Where a kitchen or dining facility has a total kitchen hood exhaust airflow rate more than 5000 ft³/min (2.3597 m³/s), then one of the following shall be provided:

1. Fifty percent or more of all replacement air is transfer air that would otherwise be exhausted.
2. Demand ventilation systems on 75 percent or more of the exhaust air. Such systems shall be capable of and configured to provide 50 percent or more reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance oper-
ation and to maintain full capture and containment of smoke, effluent, and combustion products during cooking and idle.

(3) Listed energy recovery devices that result in a sensible energy recovery ratio of 40 percent or more on 50 percent or more of the total exhaust airflow. A 40 percent sensible energy recovery ratio shall mean a change in the dry-bulb temperature of the outdoor air supply equal to 40 percent of the difference between the outdoor air and entering exhaust air dry-bulb temperatures at design conditions. [ASHRAE 90.1:6.5.7.2.3]

E 503.5.11.2.2 Performance Testing. An approved field test method shall be used to evaluate design air flow rates and demonstrate proper capture and containment performance of installed commercial kitchen exhaust systems. Where demand ventilation systems are utilized to be in accordance with Section E 503.5.11.2.2, additional performance testing shall be provided required to demonstrate proper capture and containment at minimum airflow. [ASHRAE 90.1:6.5.7.2.4]

E 503.5.11.3 Laboratory Exhaust Systems. Buildings with laboratory exhaust systems having a total exhaust rate of more than 5000 ft³/min (2.3597 m³/s) shall include not less than one of the following features:

(1) VAV laboratory exhaust and room supply systems capable of and configured to reduce exhaust and makeup airflow rates, incorporate a heat recovery system to precondition makeup air from laboratory exhaust, or both, and shall be in accordance with the following:

\[ A + B \times (E/M) \geq 50\% \]  
(Equation E 503.5.11.3)

Where:
\[ A \] = Percentage that the exhaust and makeup airflow rates are capable of being reduced from design conditions.
\[ B \] = Sensible energy recovery ratio.
\[ E \] = Exhaust airflow rate through the heat recovery device at design conditions.
\[ M \] = Makeup airflow rate of the system at design conditions.

(2) VAV laboratory exhaust and room supply systems that are required to have minimum circulation rates to be in accordance with the codes or accreditation standards shall be capable of and configured to reduce zone exhaust and makeup airflow rates to the regulated minimum circulation values, or the minimum required to maintain pressurization relationship requirements. Systems serving nonregulated zones shall be capable of and configured to reduce exhaust and makeup airflow rates to 50 percent of the zone design values, or the minimum required to maintain pressurization relationship requirements.

(3) Direct makeup (auxiliary) air supply of 75 percent or more of the exhaust airflow rate, heated not more than 2°F (1°C) below room setpoint, cooled to not less than 3°F (2°C) above room setpoint, no humidification added, and no simultaneous heating and cooling are used for dehumidification control. [ASHRAE 90.1:6.5.7.3]

E 503.5.12 Radiant Heating Systems. Radiant heating shall be used when heating is required for unenclosed spaces.

Exception: Loading docks equipped with air curtains. [ASHRAE 90.1:6.5.8.1]

E 503.5.12.1 Heating Enclosed Spaces. Radiant heating systems that are used as primary or supplemental heating for enclosed spaces shall be in accordance with the governing provisions of the standard, space heating shall be in accordance with this appendix, including, but not limited to, the following:

(1) Radiant hydronic ceiling or floor panels (used for heating or cooling).

(2) Combination or hybrid systems incorporating radiant heating (or cooling) panels.

(3) Radiant heating (or cooling) panels used in conjunction with other systems such as VAV or thermal storage systems. [ASHRAE 90.1:6.5.8.2]

E 503.5.13 Hot Gas Bypass Limitation. Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table E 503.5.13 for VAV units and single-zone VAV units. Hot-gas bypass shall not be used on constant-volume units. [ASHRAE 90.1:6.5.9]

<table>
<thead>
<tr>
<th>RATED CAPACITY</th>
<th>MAXIMUM HOT GAS BYPASS (percent of total capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤240 000 Btu/h</td>
<td>15%</td>
</tr>
<tr>
<td>&gt;240 000 Btu/h</td>
<td>10%</td>
</tr>
</tbody>
</table>

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

E 503.5.14 Door Switches. Conditioned spaces with doors, including doors with more than one-half glass, opening to the outdoors shall be provided with controls that when any such door is open, the following shall occur:

(1) Disable mechanical heating or reset the heating setpoint to 55°F (13°C) or lower within five minutes of the door opening.
APPENDIX E

(2) Disable mechanical cooling or reset the cooling setpoint to 90°F (32°C) or more within five minutes of the door opening. Mechanical cooling shall be permitted to remain enabled where outdoor air temperature is less than the space temperature.

Exceptions:
(1) Building entries with automatic closing devices.
(2) Any space without a thermostat.
(3) Alterations to existing buildings.
(4) Loading docks. [ASHRAE 90.1:6.5.10]

E 503.6 Submittals. The Authority Having Jurisdiction shall require submittal of compliance documentation and supplemental information in accordance with Section E 503.6.1 through Section E 503.6.3.

E 503.6.1 Construction Details. Compliance documents shall show the pertinent data and features of the building, equipment, and systems in sufficient detail to permit a determination of compliance by the building official and to indicate compliance with the requirements of this appendix. [ASHRAE 90.1:4.2.2.1]

E 503.6.2 Supplemental Information. Supplemental information necessary to verify compliance with this appendix, such as calculations, worksheets, compliance forms, vendor literature, or other data, shall be made available where required by the Authority Having Jurisdiction. [ASHRAE 90.1:4.2.2.2]

E 503.6.3 Manuals. Operating and maintenance information shall be provided to the building owner. This information shall include, but not be limited to, the information specified in Section E 503.6.3.1, Section E 503.6.3.2, and Section E 503.6.5.2. [ASHRAE 90.1:4.2.2.3]

E 503.6.3.1 Required Information. Construction documents shall require that an operating manual and maintenance manual be provided to the building owner. The manuals shall include, at a minimum, the following:
(1) Submittal data stating equipment rating and selected options for each piece of equipment requiring maintenance.
(2) Operation manuals and maintenance manuals for each piece of equipment requiring maintenance. Required routine maintenance actions shall be clearly identified.
(3) Names and addresses of not less than one qualified service agency.
(4) A complete narrative of how each system is intended to operate.

The Authority Having Jurisdiction shall only check to ensure that the construction documents required are provided, require this information to be transmitted to the owner, and shall not expect copies of any of the materials. [ASHRAE 90.1:8.7.2]

E 503.6.3.2 Lighting Manuals. Construction documents shall require for all lighting equipment and lighting controls that an operating and maintenance manual be provided to the building owner or the designated representative of the building owner within 90 days after the date of system acceptance. These manuals shall include, at a minimum, the following:
(1) Submittal data indicating all selected options for each piece of lighting equipment, including but not limited to lamps, ballasts, drivers, and lighting controls.
(2) Operation and maintenance manuals for each piece of lighting equipment and lighting controls with routine maintenance clearly identified including, as a minimum, a recommended relamping or cleaning program and a schedule for inspecting and recalibrating all lighting controls.
(3) A complete narrative of how each lighting control system is intended to operate including recommended settings. [ASHRAE 90.1:9.7.2.2]

E 503.6.4 Labeling of Material and Equipment. Materials and equipment shall be labeled in a manner that will allow for determination of their compliance with the applicable provisions of this appendix. [ASHRAE 90.1:4.2.3]

E 503.6.5 Completion Requirements. Section E 503.6.5.1 through Section E 503.6.5.4.1 are mandatory provisions and are necessary to comply with this appendix. [ASHRAE 90.1:6.7.2]

E 503.6.5.1 Drawings. Construction documents shall require that, within 90 days after the date of system acceptance, record drawings of the actual installation be provided to the building owner or the designated representative of the building owner. Record drawings shall include, as a minimum, the location and performance data on each piece of equipment, general configuration of duct and pipe distribution system including sizes, and the terminal air or water design flow rates. [ASHRAE 90.1:6.7.2.1]

E 503.6.5.2 Manuals. Construction documents shall require that an operating manual and a maintenance manual be provided to the building owner or the designated representative of the building owner within 90 days after the date of system acceptance. These manuals shall be in accordance with industry-accepted standards and shall include, at a minimum, the following:
(1) Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.
(2) Operation manuals and maintenance manuals for each piece of equipment and system requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
(3) Names and addresses of not less than one service agency.
(4) HVAC controls system maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined setpoints shall be
permanently recorded on control drawings at control devices or, for digital control systems, in programming comments.

(5) A complete narrative of how each system is intended to operate, including suggested set-points. [ASHRAE 90.1:6.7.2.2]

E 503.6.5.3 System Balancing. Construction documents shall require that HVAC systems be balanced in accordance with generally accepted engineering standards. Construction documents shall require that a written balance report be provided to the building owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 5000 square feet (464.52 m²). [ASHRAE 90.1:6.7.2.3.1]

E 503.6.5.3.1 Air System Balancing. Air systems shall be balanced in a manner to first minimize throttling losses. Then, for fans with fan system power greater than 1 hp (0.7 kW), fan speed shall be adjusted to meet design flow conditions. [ASHRAE 90.1:6.7.2.3.2]

E 503.6.5.3.2 Hydronic System Balancing. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.

Exceptions: Impellers need not be trimmed nor pump speed adjusted.

(1) For pumps with pump motors of 10 hp (7.5 kW) or less.

(2) Where throttling results is not greater than 5 percent of the nameplate horsepower draw, or 3 hp (2.2 kW), whichever is greater, above that required where the impeller was trimmed. [ASHRAE 90.1:6.7.2.3.3]

E 503.6.5.4 System Commissioning. HVAC control systems shall be tested to ensure that control elements are calibrated, adjusted, and in proper working condition. For projects larger than 50 000 square feet (4645.15 m²) conditioned area, except warehouses and semiheated spaces, detailed instructions for commissioning HVAC systems shall be provided by the designer in plans and specifications. [ASHRAE 90.1:6.7.2.4]

E 503.6.5.4.1 Minimum Level of Commission. Commissioning shall be performed for HVAC systems in accordance with Level 1, Basic Commissioning of the SMACNA HVAC Systems Commissioning Manual. (See Section E 801.0 for additional information on HVAC system commissioning)

E 503.7 Minimum Equipment Efficiency Tables. The minimum efficiency requirements for equipment shall comply with Section E 503.7.1; duct insulation shall comply with Section E 503.7.2, and pipe insulation shall comply with Section E 503.7.3.

E 503.7.1 Minimum Efficiency Requirement Listed Equipment – Standard Rating and Operating Conditions. The minimum efficiency requirements for equipment shall comply with Table E 503.7.1(1) through Table E 503.7.1(16).

E 503.7.2 Duct Insulation Tables. Duct insulation shall comply with Table E 503.7.2.

E 503.7.3 Pipe Insulation Tables. Pipe insulation shall comply with Table E 503.7.3(1) through Table E 503.7.3(2).

E 503.8 Alternative Compliance Path. HVAC systems serving heating, cooling, or ventilation needs of a computer room shall be in accordance with Section E 503.1, Section E 503.4, Section E 503.8.1 or Section E 503.8.2, Section E 503.8.3, Section E 502.7 through Section E 502.7.2, and Section E 503.7. [ASHRAE 90.1:6.6.1]

E 503.8.1 Computer Room (PUE1). The computer room \(PUE1\) shall be not more than the values listed in Table E 503.8.1. Hourly simulation of the proposed design, for purposes of calculating \(PUE1\), shall be in accordance with ASHRAE 90.1.

Exception: The compliance path shall not be permitted for a proposed computer room design utilizing a combined heat and power system. [ASHRAE 90.1:6.6.1.1]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>PUE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A</td>
<td>1.64</td>
</tr>
<tr>
<td>0B</td>
<td>1.62</td>
</tr>
<tr>
<td>1A</td>
<td>1.61</td>
</tr>
<tr>
<td>1B</td>
<td>1.53</td>
</tr>
<tr>
<td>2A</td>
<td>1.49</td>
</tr>
<tr>
<td>2B</td>
<td>1.45</td>
</tr>
<tr>
<td>3A</td>
<td>1.41</td>
</tr>
<tr>
<td>3B</td>
<td>1.42</td>
</tr>
<tr>
<td>3C</td>
<td>1.39</td>
</tr>
<tr>
<td>4A</td>
<td>1.36</td>
</tr>
<tr>
<td>4B</td>
<td>1.38</td>
</tr>
<tr>
<td>4C</td>
<td>1.38</td>
</tr>
<tr>
<td>5A</td>
<td>1.36</td>
</tr>
<tr>
<td>5B</td>
<td>1.33</td>
</tr>
<tr>
<td>5C</td>
<td>1.36</td>
</tr>
<tr>
<td>6A</td>
<td>1.34</td>
</tr>
<tr>
<td>6B</td>
<td>1.33</td>
</tr>
<tr>
<td>7</td>
<td>1.32</td>
</tr>
<tr>
<td>8</td>
<td>1.30</td>
</tr>
</tbody>
</table>

* \(PUE0\) and \(PUE1\) shall not include energy for battery charging.
**E 503.8.2 Computer Room (PUE₀).** The computer room PUE₀ shall be not more is less than or equal to the values listed in Table E 503.8.1. The PUE₀ shall be the highest value determined at outdoor cooling design temperatures, and shall be limited to systems utilizing only using electricity for an energy source. The PUE₀ shall be calculated for the following two conditions:

1. One hundred percent design IT equipment energy,
2. Fifty percent design IT equipment energy.

[ASHRAE 90.1:6.6.1.2]

**E 503.8.3 Documentation.** Documentation on the following components shall be provided, including a breakdown of energy consumption or demand:

1. IT equipment
2. Power distribution losses external to the IT equipment
3. HVAC systems
4. Lighting [ASHRAE 90.1:6.6.1.3]

**E 504.0 Solar Energy Systems.**

**E 504.1 General.** Solar energy systems shall be installed in accordance with the Uniform Solar Energy and Hydronics Code (USEHC).
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt;65 000 Btu/h²</td>
<td>All</td>
<td>Split system, three phase</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single package, three phase</td>
<td>14 SEER</td>
<td></td>
</tr>
<tr>
<td>Through the wall, air cooled</td>
<td>≤30 000 Btu/h²</td>
<td>All</td>
<td>Split system, three phase</td>
<td>12.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single package, three phase</td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Small duct, high velocity, air cooled</td>
<td>&lt;65 000 Btu/h²</td>
<td>All</td>
<td>Split system, three phase</td>
<td>11.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Air conditioners, air cooled</td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>11.2 EER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>12.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>11.0 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>12.4 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h and &lt;760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>10.8 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>12.2 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>9.7 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>11.2 IEER</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td></td>
<td>12.1 EER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>12.1 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>13.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>12.5 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>13.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h and &lt;760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>12.4 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>13.6 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td></td>
<td>12.2 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td></td>
<td>13.5 IEER</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE E 503.7.1(1) (continued)

**ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS**

**MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1-1]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, evaporatively cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td></td>
<td>12.1 EER 12.3 IEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>All</td>
<td>12.1 EER 12.3 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.9 EER 12.1 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>12.0 EER 12.2 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.8 EER 12.0 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.7 EER 11.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h and &lt;760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>All other</td>
<td>11.9 EER 12.1 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.7 EER 11.9 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.5 EER 11.7 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>All other</td>
<td>10.5 EER 11.8 IEER</td>
</tr>
<tr>
<td>Condensing units, air cooled</td>
<td>≥135 000 Btu/h</td>
<td>All other</td>
<td></td>
<td>13.5 EER 14.0 IEER</td>
<td>AHRI 365</td>
</tr>
<tr>
<td>Condensing units, water cooled</td>
<td>≥135 000 Btu/h</td>
<td>All other</td>
<td></td>
<td>13.5 EER 14.0 IEER</td>
<td>AHRI 365</td>
</tr>
<tr>
<td>Condensing units, evaporatively cooled</td>
<td>≥135 000 Btu/h</td>
<td>All other</td>
<td></td>
<td>13.5 EER 14.0 IEER</td>
<td>AHRI 365</td>
</tr>
</tbody>
</table>

---

Notes:

1. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
2. Single-phase, air-cooled air conditioners less than 65 000 Btu/h (19 kW) are regulated by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430. SEER values for single-phase products are set by the U.S. Department of Energy.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (cooling mode)</td>
<td>&lt;65 000 Btu/h ( ^2 )</td>
<td>All</td>
<td>Split system, three phase</td>
<td>14 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through the wall, air cooled (cooling mode)</td>
<td>≤30 000 Btu/h ( ^2 )</td>
<td>All</td>
<td>Split system, three phase</td>
<td>12.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Small duct, high velocity, air cooled</td>
<td>&lt;65 000 Btu/h ( ^2 )</td>
<td>All</td>
<td>Split System, three phase</td>
<td>11.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Air cooled (cooling mode)</td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>All other</td>
<td>11.0 EER 12.2 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>Air cooled (cooling mode)</td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>All other</td>
<td>10.6 EER 11.6 IEER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>Air cooled (cooling mode)</td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>All other</td>
<td>9.5 EER 10.6 IEER</td>
<td></td>
</tr>
<tr>
<td>Water to air, water loop (cooling mode)</td>
<td>&lt;17 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Water to air, water loop (cooling mode)</td>
<td>≥17 000 Btu/h and &lt;65 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>13.0 EER 13.0 EER</td>
<td></td>
</tr>
<tr>
<td>Water to air, water loop (cooling mode)</td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>13.0 EER 13.0 EER</td>
<td></td>
</tr>
<tr>
<td>Water to air, groundwater (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>18.0 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Brine to air, ground loop (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>77°F entering water</td>
<td>14.1 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Water to water, water loop (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>10.6 EER</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Water to water, groundwater (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>16.3 EER</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Brine to water, ground loop (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>77°F entering water</td>
<td>12.1 EER</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td>&lt;65 000 Btu/h ( ^2 ) (cooling capacity)</td>
<td>–</td>
<td>Split system, three phase</td>
<td>8.2 HSPF</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through the wall, air cooled (heating mode)</td>
<td>≤30 000 Btu/h ( ^2 ) (cooling capacity)</td>
<td>–</td>
<td>Split system, three phase</td>
<td>7.4 HSPF</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Small duct high velocity, air cooled (heating mode)</td>
<td>&lt;65 000 Btu/h ( ^2 ) (cooling capacity)</td>
<td>–</td>
<td>Split system, three phase</td>
<td>6.8 HSPF</td>
<td>AHRI 210/240</td>
</tr>
</tbody>
</table>
## APPENDIX E

### TABLE E 503.7(2) (continued)

#### ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

#### MINIMUM EFFICIENCY REQUIREMENTS

[ASHRAE 90.1: TABLE 6.8.1-2]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (heating mode)</td>
<td>≥65 000 Btu/hc and &lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.3 COPH</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/hc (cooling capacity)</td>
<td></td>
<td>17°F db/15°F wb outdoor air</td>
<td>2.25 COPH</td>
<td></td>
</tr>
<tr>
<td>Water to air, water loop (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>68°F entering water</td>
<td>4.3 COPH</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Water to air, groundwater (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>50°F entering water</td>
<td>3.7 COPH</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Brine to air, ground loop (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>32°F entering fluid</td>
<td>3.2 COPH</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Water to water, water loop (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>68°F entering water</td>
<td>3.7 COPH</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Water to water, groundwater (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>50°F entering water</td>
<td>3.1 COPH</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Brine to water, ground loop (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>32°F entering fluid</td>
<td>2.5 COPH</td>
<td>ISO 13256-2</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW, °C = (°F-32)/1.8

### Notes:

1. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
2. Single-phase, air-cooled heat pumps less than 65 000 Btu/h (19 kW) are regulated by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430. SEER and HSPF values for single-phase products are set by the U.S. Department of Energy.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>PATH A</th>
<th>PATH B</th>
<th>TEST PROCEDURE³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-cooled chillers</td>
<td>&lt;150 tons</td>
<td>EER (Btu/Wh)</td>
<td>≥10.100 FL</td>
<td>≥9.700 FL</td>
<td>AHRI 550/590</td>
</tr>
<tr>
<td></td>
<td>≥150 tons</td>
<td></td>
<td>≥13.700 IPLV/JP</td>
<td>≥15.800 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥10.100 FL</td>
<td>≥9.700 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥14.000 IPLV/JP</td>
<td>≥16.100 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td>Air-cooled without condenser, electrically operated</td>
<td>All capacities</td>
<td>EER (Btu/Wh)</td>
<td>Air-cooled chillers without condenser must be rated with matching condensers and comply with air-cooled chiller efficiency requirements</td>
<td>AHRI 550/590</td>
<td></td>
</tr>
<tr>
<td>Water-cooled, electrically operated positive displacement</td>
<td>&lt;75 tons</td>
<td>kW/ton</td>
<td>≤0.750 FL</td>
<td>≤0.780 FL</td>
<td>AHRI 550/590</td>
</tr>
<tr>
<td></td>
<td>≥75 tons and</td>
<td></td>
<td>≤0.720 FL</td>
<td>≤0.750 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;150 tons</td>
<td></td>
<td>≤0.560 IPLV/JP</td>
<td>≤0.490 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥150 tons and</td>
<td></td>
<td>≤0.660 FL</td>
<td>≤0.680 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;300 tons</td>
<td></td>
<td>≤0.540 IPLV/JP</td>
<td>≤0.440 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥300 tons and</td>
<td></td>
<td>≤0.610 FL</td>
<td>≤0.625 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;600 tons</td>
<td></td>
<td>≤0.520 IPLV/JP</td>
<td>≤0.410 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥600 tons</td>
<td></td>
<td>≤0.560 FL</td>
<td>≤0.585 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.500 IPLV/JP</td>
<td>≤0.380 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td>Water-cooled, electrically operated centrifugal</td>
<td>&lt;150 tons</td>
<td>kW/ton</td>
<td>≤0.610 FL</td>
<td>≤0.695 FL</td>
<td>AHRI 550/590</td>
</tr>
<tr>
<td></td>
<td>≥150 tons and</td>
<td></td>
<td>≤0.550 IPLV/JP</td>
<td>≤0.440 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;300 tons</td>
<td></td>
<td>≤0.610 FL</td>
<td>≤0.635 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥300 tons and</td>
<td></td>
<td>≤0.550 IPLV/JP</td>
<td>≤0.400 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;400 tons</td>
<td></td>
<td>≤0.560 FL</td>
<td>≤0.595 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥400 tons and</td>
<td></td>
<td>≤0.520 IPLV/JP</td>
<td>≤0.390 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;600 tons</td>
<td></td>
<td>≤0.560 FL</td>
<td>≤0.585 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥600 tons</td>
<td></td>
<td>≤0.500 IPLV/JP</td>
<td>≤0.380 IPLV/JP</td>
<td></td>
</tr>
<tr>
<td>Air-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP (W/W)</td>
<td>≥0.600 FL</td>
<td>NA⁴</td>
<td>AHRI 560</td>
</tr>
<tr>
<td>Water-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP (W/W)</td>
<td>≥0.700 FL</td>
<td>NA⁴</td>
<td>AHRI 560</td>
</tr>
<tr>
<td>Absorption double effect, indirect fired</td>
<td>All capacities</td>
<td>COP (W/W)</td>
<td>≥1.000 FL</td>
<td>NA⁴</td>
<td>AHRI 560</td>
</tr>
<tr>
<td>Absorption double effect, direct fired</td>
<td>All capacities</td>
<td>COP (W/W)</td>
<td>≥1.000 FL</td>
<td>NA⁴</td>
<td>AHRI 560</td>
</tr>
</tbody>
</table>

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW

Notes:
1. The requirements for centrifugal chillers shall be adjusted for nonstandard rating conditions per Section E 503.4.1 and are only applicable for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.
2. Both the full-load and IPLV/JP requirements must be met or exceeded to comply with this appendix. When there is a Path B, compliance can be with either Path A or Path B for any application.
3. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
4. NA means the requirements are not applicable for Path B, and only Path A can be used for compliance.
5. FL is the full-load performance requirements, and IPLV/JP is for the part-load performance requirements.
### TABLE E 503.7.1(4)
**Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps — Minimum Efficiency Requirements**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC (cooling mode) standard size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>[13.8 - (0.300 \times \text{Cap}/1000)^3] (before 1/1/2015) [14.0 - (0.300 \times \text{Cap}/1000)^3] (as of 1/1/2015)</td>
<td>AHRI 310/ 380</td>
</tr>
<tr>
<td>PTAC (cooling mode) nonstandard size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>10.9 – ((0.213 \times \text{Cap}/1000)^3) EER</td>
<td>AHRI 310/ 380</td>
</tr>
<tr>
<td>PTHP (cooling mode) standard size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>14.0 – ((0.300 \times \text{Cap}/1000)^3)</td>
<td>AHRI 310/ 380</td>
</tr>
<tr>
<td>PTHP (cooling mode) nonstandard size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>10.8 – ((0.213 \times \text{Cap}/1000)^3) EER</td>
<td>AHRI 310/ 380</td>
</tr>
<tr>
<td>PTHP (heating mode) standard size</td>
<td>All capacities</td>
<td>–</td>
<td>3.7 – ((0.052 \times \text{Cap}/1000)^3) COPH</td>
<td>AHRI 310/ 380</td>
</tr>
<tr>
<td>PTHP (heating mode) nonstandard size</td>
<td>All capacities</td>
<td>–</td>
<td>2.9 – ((0.026 \times \text{Cap}/1000)^3) COPH</td>
<td>AHRI 310/ 380</td>
</tr>
<tr>
<td>SPVAC (cooling mode)</td>
<td>&lt;65,000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>10.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>10.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>–</td>
<td>10.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td>SPVHP (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>10.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>10.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COPH</td>
<td>AHRI 390</td>
</tr>
<tr>
<td>Room air conditioners with louvered sides</td>
<td>&lt;6000 Btu/h</td>
<td>–</td>
<td>9.7 SEER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td></td>
<td>≥6000 Btu/h and &lt;8000 Btu/h</td>
<td>–</td>
<td>9.7 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥8000 Btu/h and &lt;14 000 Btu/h</td>
<td>–</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥14 000 Btu/h and &lt;20 000 Btu/h</td>
<td>–</td>
<td>9.7 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td></td>
</tr>
<tr>
<td>SPVAC (cooling mode), nonweatherized space constrained</td>
<td>≤30 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>9.2 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>&gt;30 000 Btu/h and ≤36 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (cooling mode), nonweatherized space constrained</td>
<td>≤30 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>9.2 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>&gt;30 000 Btu/h and ≤36 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (heating mode), nonweatherized space constrained</td>
<td>≤30 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COPH</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>&gt;30 000 Btu/h and ≤36 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COPH</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE E 503.7.1(4) (continued)

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room air conditioners</td>
<td>&lt;8000 Btu/h</td>
<td>–</td>
<td>9.0 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td>without louvered sides</td>
<td>≥8000 Btu/h and &lt;20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td></td>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td>Room air conditioner heat pumps with louvered sides</td>
<td>&lt;20 000 Btu/h</td>
<td>–</td>
<td>9.0 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td></td>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td>Room air conditioner heat pumps without louvered sides</td>
<td>&lt;14 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td></td>
<td>≥14 000 Btu/h</td>
<td>–</td>
<td>8.0 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td>Room air conditioner, casement only</td>
<td>All capacities</td>
<td>–</td>
<td>8.7 EER</td>
<td>AHAM RAC-1</td>
</tr>
<tr>
<td>Room air conditioner, casement slider</td>
<td>All capacities</td>
<td>–</td>
<td>9.5 EER</td>
<td>AHAM RAC-1</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW, °C = (°F-32)/1.8

Notes:
1. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
2. Nonstandard size units must be factory labeled as follows: “MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW STANDARD PROJECTS.” Nonstandard size efficiencies apply only to units being installed in existing sleeves having an external wall opening of less than 16 inch (406 mm) high or less than 42 inch (1067 mm) wide and having a cross-sectional area less than 670 square inches (0.432 m²).
3. “Cap” means the rated cooling capacity of the product in Btu/h (kW). If the unit’s capacity is less than 7000 Btu/h (2.05 kW), use 7000 Btu/h (2.05 kW) in the calculation. Where the unit’s capacity is more than 15 000 Btu/h (4.4 kW), use 15 000 Btu/h (4.4 kW) in the calculation.

### TABLE E 503.7.1(5)

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-air furnace, gas fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity3</td>
<td>78% AFUE or 80% Et4</td>
<td>DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, CSA Z21.47</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td>Maximum capacity3</td>
<td>80% Et4</td>
<td>Section 2.39, Thermal Efficiency, CSA Z21.47</td>
</tr>
<tr>
<td>Warm-air furnace, oil fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity3</td>
<td>78% AFUE or 80% Et4</td>
<td>DOE 10 CFR Part 430 or Section 42, Combustion, UL 727</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td>Maximum capacity3</td>
<td>81% Et4</td>
<td>Section 42, Combustion, UL 727</td>
</tr>
<tr>
<td>Warm-air duct furnaces, gas fired</td>
<td>All capacities</td>
<td>Maximum capacity3</td>
<td>80% Ec5</td>
<td>Section 2.10, Efficiency, CSA Z83.8</td>
</tr>
<tr>
<td>Warm-air unit heaters, gas fired</td>
<td>All capacities</td>
<td>Maximum capacity3</td>
<td>80% Ec5</td>
<td>Section 2.10, Efficiency, CSA Z83.8</td>
</tr>
<tr>
<td>Warm-air unit heaters, oil fired</td>
<td>All capacities</td>
<td>Maximum capacity3</td>
<td>80% Ec5</td>
<td>Section 40, Combustion, UL 731</td>
</tr>
</tbody>
</table>

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

Notes:
1. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
2. Combination units not covered by the U.S. Department of Energy Code of Federal Regulations 10 CFR 430 [three-phase power or cooling capacity greater than or equal to 65 000 Btu/h (19 kW)] may comply with either rating.
3. Compliance of multiple firing rate units shall be at the maximum firing rate.
4. Et = thermal efficiency. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75 percent of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
5. Ec = combustion efficiency (100 percent less flue losses). See test procedure for detailed discussion.
6. As of August 8, 2008, according to the Energy Policy Act of 2005, units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.
## APPENDIX E

### TABLE E 503.7.1(6)

**GAS- AND OIL-FIRED BOILERS — MINIMUM EFFICIENCY REQUIREMENTS², ³**

ASHRAE 90.1: TABLE 6.8.1-6

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE¹</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>MINIMUM EFFICIENCY</th>
<th>EFFICIENCY AS OF 3/2/2020</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers, hot water</td>
<td>Gas fired</td>
<td>&lt;300 000 Btu/h²</td>
<td>82% AFUE</td>
<td>82% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h⁴</td>
<td>80% Et</td>
<td>80% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h¹</td>
<td>82% Ec</td>
<td>82% Ec</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>Oil fired⁵</td>
<td>&lt;300 000 Btu/h⁷</td>
<td>84% AFUE</td>
<td>84% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h⁴</td>
<td>82% Et</td>
<td>82% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h¹</td>
<td>84% Ec</td>
<td>84% Ec</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td>Boilers, steam</td>
<td>Gas fired — all, except natural draft</td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h⁴</td>
<td>79% Et</td>
<td>79% Et</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h¹</td>
<td>79% Et</td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>Gas fired — natural draft</td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h⁴</td>
<td>77% Et</td>
<td>79% Et</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h¹</td>
<td>77% Et</td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td>Oil fired⁵</td>
<td>&lt;300 000 Btu/h</td>
<td>82% AFUE</td>
<td>82% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h⁴</td>
<td>81% Et</td>
<td>81% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h¹</td>
<td>81% Et</td>
<td>81% Et</td>
<td>10 CFR Part 431</td>
</tr>
</tbody>
</table>

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

### Notes:

1. These requirements apply to boilers with rated input of 8 000 000 Btu/h (2343 kW) or less that are not packaged boilers and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.
2. Ec = combustion efficiency (100 percent less flue losses). See reference document for detailed information.
4. Maximum capacity—minimum and maximum ratings as provided for and allowed by the unit’s controls.
5. Includes oil-fired (residual).
6. Boilers shall not be equipped with a constant burning pilot light.
7. A boiler not equipped with a tankless domestic water-heating coil shall be equipped with an automatic means for adjusting the temperature of the water such that an incremental change in inferred heat load produces a corresponding incremental change in the temperature of the water supplied.
### TABLE E 503.7.1(7)
**PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT**

**MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1-7]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>TOTAL SYSTEM HEAT-REJECTION CAPACITY AT RATED CONDITIONS</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIRED</th>
<th>TEST PROCEDURE</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller or axial fan open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water 85°F leaving water 75°F entering wb</td>
<td>≥40.2 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201 RS</td>
<td>1. For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the thermal rating condition listed in Table E 503.7.1(7) divided by the fan motor nameplate power. 2. For purposes of this table, closed-circuit cooling tower performance is defined as the process water flow rating of the tower at the thermal rating condition listed in Table E 503.7.1(7) divided by the sum of the fan motor nameplate power and the integral spray pump motor nameplate power. 3. For purposes of this table, air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan motor nameplate power. 4. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure. 5. The efficiencies and test procedures for both open- and closed-circuit cooling towers are not applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements do not apply to field-erected cooling towers. 6. All cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of any project-specific accessories and/or options included in the capacity of the cooling tower. 7. For purposes of this table, evaporative condenser performance is defined as the heat rejected at the specified rating condition in the table, divided by the sum of the fan motor nameplate power and the integral spray pump nameplate power. 8. Requirements for evaporative condensers are listed with ammonia (R-717) and R-507A as test fluids in the table. Evaporative condensers intended for use with halocarbon refrigerants other than R-507A must meet the minimum efficiency requirements listed above with R-507A as the test fluid.</td>
</tr>
<tr>
<td>Centrifugal fan open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water 85°F leaving water 75°F entering wb</td>
<td>≥20.0 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201 RS</td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water 90°F leaving water 75°F entering wb</td>
<td>≥16.1 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201 RS</td>
<td></td>
</tr>
<tr>
<td>Centrifugal closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water 90°F leaving water 75°F entering wb</td>
<td>≥7.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201 RS</td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan evaporative condensers</td>
<td>All</td>
<td>R-507A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb</td>
<td>≥157 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan evaporative condensers</td>
<td>All</td>
<td>Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb</td>
<td>≥134 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan evaporative condensers</td>
<td>All</td>
<td>R-507A test fluid 165°F entering gas temperature 105°F condensing temperature 75°F entering wb</td>
<td>≥135 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan evaporative condensers</td>
<td>All</td>
<td>Ammonia test fluid 140°F entering gas temperature 96.3°F condensing temperature 75°F entering wb</td>
<td>≥110 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
<td></td>
</tr>
<tr>
<td>Air cooled condensers</td>
<td>All</td>
<td>125°F condensing temperature 190°F entering gas temperature 15°F subcooling 95°F entering db</td>
<td>≥176 000 Btu/h·hp</td>
<td>AHRI 460</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8, 1 gallon per minute per horsepower = 0.085 [(L/s)/kW], 1000 British thermal units per hour = 0.293 kW, 1 horsepower = 0.746 kW
### APPENDIX E

#### TABLE E 503.7.1(8)

**HEAT TRANSFER EQUIPMENT — MINIMUM EFFICIENCY REQUIREMENTS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid-to-liquid heat exchangers</td>
<td>Plate type</td>
<td>NR</td>
<td>AHRI 400</td>
</tr>
</tbody>
</table>

**Notes:**

1. NR = No Requirement
2. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

#### TABLE E 503.7.1(9)

**ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS — MINIMUM EFFICIENCY REQUIREMENTS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF air conditioners, air cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system</td>
<td>13.0 SEER</td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF multisplit system</td>
<td>11.2 EER (before 1/1/2017) 13.1 IEER (as of 1/1/2017) 15.5 IEER (as of 1/1/2017)</td>
<td>AHRI 1230</td>
<td></td>
</tr>
<tr>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF multisplit system</td>
<td>11.0 EER (before 1/1/2017) 12.9 IEER (as of 1/1/2017) 14.9 IEER (as of 1/1/2017)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF multisplit system</td>
<td>10.0 EER (before 1/1/2017) 11.6 IEER (as of 1/1/2017) 13.9 IEER (as of 1/1/2017)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW
### TABLE E 503.7.1(10)

**ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS – MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1-10]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF air cooled (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF multisplit</td>
<td>13.0 SEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td></td>
<td>VRF multisplit system with heat recovery</td>
<td>10.8 EER, 12.7 IEER (before 1/1/2017), 14.4 IEER (as of 1/1/2017)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF multisplit system</td>
<td>10.6 EER, 12.3 IEER (before 1/1/2017), 13.9 IEER (as of 1/1/2017)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td></td>
<td>VRF multisplit system with heat recovery</td>
<td>10.4 EER, 12.1 IEER (before 1/1/2017), 13.7 IEER (as of 1/1/2017)</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td>VRF water source (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td></td>
<td>VRF multisplit systems 86°F entering water</td>
<td>12.0 EER, 16.0 IEER (as of 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td></td>
<td>VRF multisplit systems with heat recovery 86°F entering water</td>
<td>11.8 EER, 15.8 IEER (as of 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td></td>
<td>VRF multisplit system 86°F entering water</td>
<td>11.8 EER, 15.8 IEER (as of 1/1/2018)</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td></td>
<td>VRF multisplit system with heat recovery 86°F entering water</td>
<td>10.0 EER, 14.0 IEER (as of 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>VRF multisplit system 86°F entering water</td>
<td>9.8 EER, 13.8 IEER (as of 1/1/2018)</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE E 503.7.1(10) (continued)
#### ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AND APPLIED HEAT PUMPS — MINIMUM EFFICIENCY REQUIREMENTS

[ASHRAE 90.1: TABLE 6.8.1-10]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF ground-water source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 59°F entering water</td>
<td>16.2 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system with heat recovery 59°F entering water</td>
<td>13.8 EER</td>
<td></td>
</tr>
<tr>
<td>VRF ground source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 77°F entering water</td>
<td>13.4 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF multisplit system 77°F entering water</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td>VRF Air cooled (heating mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system</td>
<td>7.7 HSPF</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 47°F entering water</td>
<td>3.3 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 47°F db/43°F wb outdoor air</td>
<td>3.2 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 47°F db/43°F wb outdoor air</td>
<td>2.05 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>VRF Water source (heating mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 68°F entering water</td>
<td>4.2 COP&lt;sub&gt;H&lt;/sub&gt; (before 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 68°F entering water</td>
<td>4.2 COP&lt;sub&gt;H&lt;/sub&gt; (as of 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 68°F entering water</td>
<td>3.9 COP&lt;sub&gt;H&lt;/sub&gt; (before 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>—</td>
<td>VRF multisplit system 68°F entering water</td>
<td>3.9 COP&lt;sub&gt;H&lt;/sub&gt; (as of 1/1/2018)</td>
<td></td>
</tr>
<tr>
<td>VRF Groundwater source (heating mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 50°F entering water</td>
<td>3.6 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 50°F entering water</td>
<td>3.3 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>VRF Ground source (heating mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 32°F entering water</td>
<td>3.1 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-split system 32°F entering water</td>
<td>2.8 COP&lt;sub&gt;H&lt;/sub&gt;</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW, °C=(°F-32)/1.8
### Table E.503.7.1(11)

**Air Conditioners and Condensing Units Serving Computer Rooms**

**Minimum Efficiency Requirements**

[ASHRAE 90.1: Table 6.8.1-11]

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Net Sensible Cooling Capacity</th>
<th>Standard Model</th>
<th>Minimum Net Sensible COP&lt;sub&gt;c&lt;/sub&gt;</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;65 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.30</td>
<td>AHRI 1360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>2.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.45</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>1.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.15</td>
<td></td>
</tr>
<tr>
<td>Water cooled</td>
<td></td>
<td>Downflow unit</td>
<td>2.50</td>
<td>AHRI 1360</td>
</tr>
<tr>
<td></td>
<td>&lt;65 000 Btu/h</td>
<td>Upflow unit—ducted</td>
<td>2.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>2.15</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.45</td>
<td></td>
</tr>
<tr>
<td>Water cooled with fluid economizer</td>
<td>&lt;65 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.45</td>
<td>AHRI 1360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.15</td>
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<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—ducted</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit—nonducted</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.40</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE E 503.7.1(11) (continued)

**AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS**

**MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1-11]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY</th>
<th>STANDARD MODEL</th>
<th>MINIMUM NET SENSIBLE COP&lt;sub&gt;c&lt;/sub&gt;</th>
<th>RETURN AIR DRY-BULB TEMPERATURE/DEW-POINT TEMPERATURE</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CLASS 1</td>
<td>CLASS 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75°F/52°F</td>
<td>85°F/52°F</td>
</tr>
<tr>
<td>Glycol cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–ducted</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–nonducted</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Downflow unit</td>
<td>2.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–ducted</td>
<td>1.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–nonducted</td>
<td>1.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Horizontal-flow unit</td>
<td>2.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>Downflow unit</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–ducted</td>
<td>1.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–nonducted</td>
<td>1.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycol cooled with fluid economizer</td>
<td>Downflow unit</td>
<td>2.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td></td>
<td>Upflow unit–ducted</td>
<td>2.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–nonducted</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Downflow unit</td>
<td>1.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–ducted</td>
<td>1.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–nonducted</td>
<td>1.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>Downflow unit</td>
<td>1.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–ducted</td>
<td>1.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upflow unit–nonducted</td>
<td>1.70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE E 503.7.1(12)**

**COMMERCIAL REFRIGERATOR AND FREEZERS – MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1-12]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>APPLICATION</th>
<th>ENERGY USE LIMITS, KWH/DAY&lt;sup&gt;*&lt;/sup&gt;</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator with solid doors</td>
<td>Holding temperature</td>
<td>0.10 × V + 2.04</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Refrigerator with transparent doors</td>
<td>Holding temperature</td>
<td>0.12 × V + 3.34</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Freezers with solid doors</td>
<td>Holding temperature</td>
<td>0.40 × V + 1.38</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Freezers with transparent doors</td>
<td>Holding temperature</td>
<td>0.75 × V + 4.10</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Refrigerators/freezers with solid doors</td>
<td>Holding temperature</td>
<td>the greater of 0.12 × V + 3.34 or 0.70</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Commercial refrigerators</td>
<td>Pulldown</td>
<td>0.126 × V + 3.51</td>
<td>AHRI 1200</td>
</tr>
</tbody>
</table>

* V = the chiller or frozen compartment volume (ft<sup>3</sup>) as defined in Association of Home Appliance Manufacturers.

For SI units: 1000 British thermal units per hour = 0.293 kW, °C=(°F-32)/1.8
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>FAMILY CODE</th>
<th>OPERATING MODE</th>
<th>RATING TEMPERATURE</th>
<th>ENERGY USE LIMITS, kwh/day</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOP.RC.M</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.82 x TDA + 4.07</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SVO.RC.M</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.83 x TDA + 3.18</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.RC.M</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.35 x TDA + 2.88</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VOP.RC.L</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>2.27 x TDA + 6.85</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.RC.L</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>0.57 x TDA + 6.88</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCT.RC.M</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.22 x TDA + 1.95</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCT.RC.L</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>0.56 x TDA + 2.61</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SOC.RC.M</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.51 x TDA + 0.11</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VOPSC.M</td>
<td>Vertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>1.74 x TDA + 4.71</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SVO.SC.M</td>
<td>Semivertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>1.73 x TDA + 4.59</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.SC.M</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>0.77 x TDA + 5.55</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.SC.L</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Low temperature</td>
<td>1.92 x TDA + 7.08</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCT.SC.I</td>
<td>Vertical transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>0.67 x TDA + 3.29</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCS.SC.I</td>
<td>Vertical solid door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>0.38 x V + 0.88</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCT.SC.I</td>
<td>Horizontal transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>0.56 x TDA + 0.43</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SVO.RC.L</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>2.27 x TDA + 6.85</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VOP.RC.I</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>2.89 x TDA + 8.7</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SVO.RC.I</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>2.89 x TDA + 8.7</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.RC.I</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.72 x TDA + 8.74</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCT.RC.I</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.66 x TDA + 3.05</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCT.RC.M</td>
<td>Horizontal transparent door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.16 x TDA + 0.13</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCT.RC.L</td>
<td>Horizontal transparent door</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>0.34 x TDA + 0.26</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCT.RC.I</td>
<td>Horizontal transparent door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.4 x TDA + 0.31</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCS.RC.M</td>
<td>Vertical solid door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.11 x V + 0.26</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCS.RC.L</td>
<td>Vertical solid door</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>0.23 x V + 0.54</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VCS.RC.I</td>
<td>Vertical solid door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.27 x V + 0.63</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCS.RC.M</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.11 x V + 0.26</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCS.RC.L</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>0.23 x V + 0.54</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCS.RC.I</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.27 x V + 0.63</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCS.RC.I</td>
<td>Horizontal solid door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>0.27 x V + 0.63</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SOC.RC.L</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>1.08 x TDA + 0.22</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SOC.RC.I</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>1.26 x TDA + 0.26</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VOP.SC.I</td>
<td>Vertical open</td>
<td>Self contained</td>
<td>Low temperature</td>
<td>4.37 x TDA + 11.82</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VOPSC.M</td>
<td>Vertical open</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>5.55 x TDA + 15.02</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SVO.SC.M</td>
<td>Semivertical open</td>
<td>Self contained</td>
<td>Low temperature</td>
<td>4.34 x TDA + 11.51</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SVO.SC.I</td>
<td>Semivertical open</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>5.52 x TDA + 14.63</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HZO.SC.I</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>2.44 x TDA + 9.0</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>SOC.SC.I</td>
<td>Service over counter</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>1.76 x TDA + 0.36</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>HCS.SC.I</td>
<td>Horizontal solid door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>0.38 x V + 0.88</td>
<td>AHRI 1200</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour per day = 0.293 kW/day, °C = (°F-32)/1.8

Notes:
1. Equipment class designations consist of a combination [in sequential order separated by periods (AAA).(BB).(C)] of the following:
   (a) (AAA)—An equipment family code (VOP = vertical open, SVO = semivertical open, HZO = horizontal open, VCT = vertical transparent doors, VCS = vertical solid doors, HCT = horizontal transparent doors, HCS = horizontal solid doors, and SOC = service over counter).
   (b) (BB)—An operating mode code (RC = remote condensing and SC = self contained).
   (c) (C)—A rating temperature code (M = medium temperature [38°F], L = low temperature [0°F], or I = ice cream temperature [15°F]). For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" equipment class.

2. V is the volume of the case (ft) as measured in accordance with AHRI 1200.

3. TDA is the total display area of the case (ft) as measured in accordance with AHRI 1200.
### APPENDIX E

#### TABLE E 503.7.1(14)

**VAPOR COMPRESSION BASED INDOOR POOL DEHUMIDIFIERS — MINIMUM EFFICIENCY REQUIREMENTS**  
*ASHRAE 90.1: TABLE 6.8.1-14*

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
</table>
| Single package indoor*  
(with or without economizer) | Rating Conditions: A, B, or C | 3.5 MRE | AHRI 910 |
| Single package indoor water-cooled  
(with or without economizer) | | 3.5 MRE | |
| Single package indoor air-cooled  
(with or without economizer) | | 3.5 MRE | |
| Split system indoor air-cooled  
(with or without economizer) | | 3.5 MRE | |

* Units without air-cooled condenser

#### TABLE E 503.7.1(15)

**ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITHOUT ENERGY RECOVERY — MINIMUM EFFICIENCY REQUIREMENTS**  
*ASHRAE 90.1: TABLE 6.8.1-15*

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
</table>
| Air cooled  
(dehumidification mode) | – | 4.0 ISMRE | AHRI 920 |
| Air source heat pumps  
(dehumidification mode) | – | 4.0 ISMRE | AHRI 920 |
| Water cooled  
(dehumidification mode) | Cooling tower condenser water | 4.9 ISMRE | AHRI 920 |
| | Chilled Water | 6.0 ISMRE | |
| Air source heat pump  
(heating mode) | | 2.7 ISCOP | AHRI 920 |
| Water source heat pump  
(dehumidification mode) | Ground source, closed loop | 4.8 ISMRE | AHRI 920 |
| | Ground-water source | 5.0 ISMRE | |
| | Water source | 4.0 ISMRE | |
| Water source heat pump  
(heating mode) | Ground source, closed loop | 2.0 ISCOP | AHRI 920 |
| | Ground-water source | 3.2 ISCOP | |
| | Water source | 3.5 ISCOP | |

#### TABLE E 503.7.1(16)

**ELECTRICALLY OPERATED DX-DOAS UNITS, SINGLE-PACKAGE AND REMOTE CONDENSER, WITH ENERGY RECOVERY — MINIMUM EFFICIENCY REQUIREMENTS**  
*ASHRAE 90.1: TABLE 6.8.1-16*

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
</table>
| Air cooled  
(dehumidification mode) | – | 5.2 ISMRE | AHRI 920 |
| Air source heat pumps  
(dehumidification mode) | – | 5.2 ISMRE | AHRI 920 |
| Water cooled  
(dehumidification mode) | Cooling tower condenser water | 5.3 ISMRE | AHRI 920 |
| | Chilled Water | 6.6 ISMRE | |
| Air source heat pump  
(heating mode) | – | 3.3 ISCOP | AHRI 920 |
| Water source heat pump  
(dehumidification mode) | Ground source, closed loop | 5.2 ISMRE | AHRI 920 |
| | Ground-water source | 5.8 ISMRE | |
| | Water source | 4.8 ISMRE | |
| Water source heat pump  
(heating mode) | Ground source, closed loop | 3.8 ISCOP | AHRI 920 |
| | Ground-water source | 4.0 ISCOP | |
| | Water source | 4.8 ISCOP | |
**APPENDIX E**

**TABLE E 503.72**

**MINIMUM DUCT INSULATION R-VALUE**

[ASHRAE 90.1: TABLE 6.8.2]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DUCT LOCATION</th>
<th>UNCONDITIONED SPACE AND BURIED DUCTS</th>
<th>INDIRECTLY CONDITIONED SPACE(^3, 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EXTERIOR(^2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUPPLY AND RETURN DUCTS FOR HEATING AND COOLING</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 4</td>
<td>R-8</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
<tr>
<td>5 to 8</td>
<td>R-12</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
<tr>
<td>SUPPLY AND RETURN DUCTS FOR HEATING ONLY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 1</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>2 to 4</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
<tr>
<td>5 to 8</td>
<td>R-12</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
<tr>
<td>SUPPLY AND RETURN DUCTS FOR COOLING ONLY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 to 6</td>
<td>R-8</td>
<td>R-6</td>
<td>R-1.9</td>
</tr>
<tr>
<td>7 to 8</td>
<td>R-1.9</td>
<td>R-1.9</td>
<td>R-1.9</td>
</tr>
</tbody>
</table>

Notes:
1. Insulation R-values, measured in \([°F•h•ft^2/(Btu•in)]\) \([(m•K)/W]\), are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where portions of the building envelope are used as a plenum enclosure, building envelope insulation shall be as required by the most restrictive condition of Section E 503.4.7.1 or ASHRAE 90.1, depending on whether the plenum is located in the roof, wall, or floor. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F (24°C) at the installed thickness.
2. Includes attics above insulated ceilings, parking garages and crawl spaces.
3. Includes return air plenums, with or without exposed roofs above.
4. Return ducts in this duct location do not require insulation.

**TABLE E 503.7.3(1)**

**MINIMUM PIPE INSULATION THICKNESS FOR HEATING AND HOT WATER SYSTEMS\(^1, 2, 3, 4, 5\)**

(STEAM, STEAM CONDENSATE, HOT WATER HEATING, AND DOMESTIC WATER SYSTEMS)

[ASHRAE 90.1: TABLE 6.8.3-1]

<table>
<thead>
<tr>
<th>FLUID OPERATING TEMPERATURE RANGE (°F) AND USAGE</th>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONDUCTIVITY</td>
<td>MEAN RATING TEMPERATURE °F</td>
</tr>
<tr>
<td></td>
<td>Btu•inch/(h•ft²•°F)</td>
<td></td>
</tr>
<tr>
<td>&gt;350</td>
<td>0.32 - 0.34</td>
<td>250</td>
</tr>
<tr>
<td>251 - 350</td>
<td>0.29 - 0.32</td>
<td>200</td>
</tr>
<tr>
<td>201 - 250</td>
<td>0.27 - 0.30</td>
<td>150</td>
</tr>
<tr>
<td>141 - 200</td>
<td>0.25 - 0.29</td>
<td>125</td>
</tr>
<tr>
<td>105 - 140</td>
<td>0.22 - 0.28</td>
<td>100</td>
</tr>
</tbody>
</table>

For SI units: °C=(°F-32)/1.8, 1 inch = 25 mm, 1 British thermal unit inch per hour square foot degree Fahrenheit = [0.1 W/(m•K)]

Notes:
1. For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:
   \[ T = r\left(1 + \frac{r}{k}\right)^{K - 1} \]
   Where:
   - \( T \) = minimum insulation thickness (inches).
   - \( r \) = actual outside radius of pipe (inches).
   - \( t \) = insulation thickness listed in this table for applicable fluid temperature and pipe size.
   - \( K \) = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu•in/(h•ft²•°F)] [W/(m•K)].
   - \( k \) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.
2. These thicknesses shall be based on energy efficiency considerations only. Additional insulation shall be permitted to be sometimes required relative to safety issues/surface temperature.
3. Note: For piping smaller than 1/2 inches (40 mm) or less and located in partitions within conditioned spaces, reduction of insulation thicknesses by 1 inch (25.4 mm) shall be permitted (before thickness adjustment required in footnote 1) but not a thickness less than 1/16 inch (1.5 mm).
4. For direct-buried heating and hot water system piping, reduction of insulation thicknesses by 1/2 inch (40 mm) shall be permitted (before thickness adjustment required in footnote 1) but not a thickness less than 0.25 inch (6.4 mm).
5. Table E 503.7.3(1) is based on steel pipe. Non-metallic pipes having thermal resistance more than that of steel pipe, reduced insulation thicknesses shall be permitted where documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.3(1).
TABLE E 503.7.3(2)
MINIMUM PIPE INSULATION THICKNESS FOR COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)\textsuperscript{1,2,3,4}
[ASHRAE 90.1: TABLE 6.8.3-2]

<table>
<thead>
<tr>
<th>FLUID OPERATING TEMPERATURE RANGE (°F) AND USAGE</th>
<th>INSULATION CONDUCTIVITY (Btu\cdot inch/(h\cdot °F\cdot ft\cdot °F))</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
<th>&lt;1</th>
<th>1 to &lt;1½</th>
<th>1½ to &lt;4</th>
<th>4 to &lt;8</th>
<th>≥8</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°F - 60°F</td>
<td>0.21 - 0.27</td>
<td>≤0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>&lt;40°F</td>
<td>0.20 - 0.26</td>
<td>≤0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32) / 1.8, 1 inch = 25 mm, 1 British thermal unit inch per hour square foot degree Fahrenheit = [0.1 W/(m\cdot K)]

Notes:
1. For insulation outside the stated conductivity range, the minimum thickness (\(T\)) shall be determined as follows:
   \[ T = r \left( 1 + \frac{r}{Kt} \right) \frac{K}{k} - 1 \]
   Where:
   - \(T\) = minimum insulation thickness (inches).
   - \(r\) = actual outside radius of pipe (inches).
   - \(t\) = insulation thickness listed in this table for applicable fluid temperature and pipe size.
   - \(K\) = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu\cdot inch/(h\cdot °F\cdot ft)] [W/(m\cdot K)].
   - \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

2. These thicknesses shall be based on energy efficiency considerations only. Issues such as water, vapor permeability, or surface condensation require vapor retarders or additional insulation.

3. Insulation shall not be required for direct-buried cooling system piping. Insulation is not required for direct-buried cooling system piping.

4. Table E 503.7.3(2) is based on steel pipe. Non-metallic pipes less than schedule 80 thickness or less shall use the table values. For other non-metallic pipes having thermal resistance more than that of steel pipe, reduced insulation thicknesses shall be permitted where documentation is provided showing that the pipe with the proposed insulation has less or more heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.3(2).

E-505.0 Geothermal Systems.
E-505.1 Applicability. Geothermal systems that use the earth or body of water as a heat source or sink for heating or cooling shall be in accordance with Section E-505.1.1 through Section E-505.2.

E-505.1.1 Design, Installation, and Testing. Geothermal systems shall be designed by a registered design professional. The geothermal system design, installation, and testing shall be in accordance with CSA C448.

E-505.2 Ground Source Heat Pump-Loop Systems. Ground source heat pump-ground loop piping and tubing material for water-based systems shall comply with the standards cited in this appendix.

E-505.3 Material Rating. Piping shall be rated for the operating temperature and pressure of the ground source heat pump loop system. Fittings shall be rated for the temperature and pressure applications and recommended by the manufacturer for installation with the piping material installed. Where used underground, materials shall be approved for burial.

E-506.0 Joints and Connections.
E-506.1 Approval. Joints and connections shall be of an approved type. Joints and connections shall be tight for the pressure of the ground source-loop system. Joints and fittings used underground shall be approved for buried applications.

E-506.2 Joints Between Various Materials. Joints between various piping materials shall be made with approved transition fittings.

E-506.3 Preparation of Pipe Ends. Pipe shall be cut square, reamed, and free of burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut. CPVC, PE, and PVC pipe shall be chamfered.

E-506.4 Joint Preparation and Installation. Where required by Section E-506.5 through Section E-506.12.2, the preparation and installation of mechanical and thermoplastic-welded joints shall be in accordance with Section E-506.1.4 and Section E-506.5.

E-506.5 Mechanical Joints. Mechanical joints shall be installed in accordance with the manufacturer's installation instructions.

E-506.6 Thermoplastic Welded Joints. Joint surfaces for thermoplastic welded joints shall be cleaned by an approved procedure. Joints shall be welded in accordance with the manufacturer's installation instructions.

E-506.7 CPVC Plastic Pipe. Joints between CPVC plastic piping and fittings shall comply with Section E-506.7.1 and Section E-506.7.2.

E-506.7.1 Threaded Joints. Threads shall comply with ASME B1.20.1. Schedule 80 or heavier plastic pipe shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

E-506.7.2 Solvent Cement. Solvent cement joints for CPVC pipe and fittings shall be clean from dirt and mois-
Where Heat-fusion Joints

A pipe in a ground source heat pump loop system having an exterior surface temperature exceeding 250°F (121°C), shall have a clearance of not less than 1 inch (25.4 mm) from combustible materials.

E-506.8.2 Plastic-to-Metal Connections. Soldering on the metal portion of the system shall be performed not less than 18 inches (457 mm) from a plastic-to-metal transition joint.

E-506.9.1 Heat-Fusion Joints. Joints shall be of the socket-fusion, saddle-fusion, or butt-fusion type and joined in accordance with ASTM D2657. Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

E-506.9.2 Electrofusion Joints. Joints shall be of the electrofusion type. Joint surfaces shall be clean and free of moisture, and secured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

E-506.9.3 Stab-Type Insert Fittings. Joint surfaces shall be clean and free of moisture. Pipe ends shall be chamfered and inserted into the fittings to full depth. Fittings shall be manufactured in accordance with ASTM F1024.

E-506.10 Polypropylene (PP) Plastic. Joints between PP plastic pipe and fittings shall comply with Section E-506.10.1 and Section E-506.10.2.

E-506.10.1 Heat-Fusion Joints. Heat-fusion joints for polypropylene (PP) pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings, electrofusion polypropylene fittings, or by butt fusion. Joint surfaces shall be clean and free of moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F2389.

E-506.10.2 Mechanical and Compression Sleeve Joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions.

E-506.11 Raised Temperature Polyethylene (PE-RT) Plastic Tubing. Joints between raised temperature polyethylene tubing and fittings shall comply with Section E-506.11.1 and Section E-506.11.2. Mechanical joints shall comply with Section E-506.5.

E-506.11.1 Compression-Type Fittings. Where compression-type fittings are used, the fittings shall be installed with the inserts and ferrules or o-rings at the manufacturer's instructions.

E-506.11.2 PE-RT-to-Metal Connections. Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-RT pipe.

E-506.12 PVC Plastic Pipe. Joints between PVC plastic pipe and fittings shall comply with Section E-506.12.1 and Section E-506.12.2.

E-506.12.1 Solvent Cement Joints. Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Purple primer in accordance with ASTM F656 shall be applied until the surface of the pipe and fitting is softened. Solvent cement in accordance with ASTM D2564 shall be applied to joint surfaces.

E-506.12.2 Threaded Joints. Threads shall comply with ASME B1.20.1. Schedule 80 or heavier plastic pipe shall be threaded with dies specifically designed for plastic pipe. Thread lubricant, pipe-joint compound or tape shall be applied on the male threads only and shall be approved for application on the piping material.

E-508.0 Installation.

E-508.1 General. Piping, valves, fittings, and connections shall be installed in accordance with the manufacturer’s installation instructions.

E-508.2 Protection of Potable Water. Where ground source heat pump ground loop systems have a connection to a potable water supply, the potable water system shall be protected.

E-508.3 Pipe Penetrations. Openings for pipe penetrations in walls, floors, and ceilings shall be larger than the penetrating pipe. Openings for pipe penetrations shall be sleeved. The annular space surrounding the penetrating pipe shall be protected in accordance with the building code.

E-508.4 Clearance from Combustibles. A pipe in a ground source heat pump piping system, having an exterior surface temperature exceeding 250°F (121°C), shall have a clearance of not less than 1 inch (25.4 mm) from combustible materials.

E-509.0 Testing.

E-509.1 Ground Source Heat Pump Loop System Testing. Before connection header trenches are backfilled, the assembled loop system shall be pressure tested with water at 100 psi (689 kPa) for 15 minutes with no observed leaks. Flow and pressure loss testing shall be performed, and the actual flow rates and pressure drops shall be compared to the calculated design values. Where actual flow rate or pressure drop values
differ from calculated design values by more than 10 percent, the cause shall be identified and corrective action taken.

E 601.0 Indoor Environment.
E 601.1 Scope. The provisions of this section shall establish the means of reducing the quantity of air contaminants that are odorous, irritating, or harmful to the comfort and well-being of a building’s installers, occupants, and neighbors.

E 602.0 Fireplaces.
E 602.1 Requirements. A direct-vent sealed-combustion gas or sealed wood-burning fireplace, or a sealed wood stove shall be installed. The fireplace shall comply with Section E 602.1.1 and Section E 602.1.2.

E 602.1.1 Masonry or Factory-Built Fireplace. Masonry and factory-built fireplaces located in conditioned spaces shall be in accordance with Section E 602.1.1.1 through Section E 602.1.1.3.

E 602.1.1.1 Opening Cover. Closeable metal or glass doors covering the entire opening of the firebox shall be installed.

E 602.1.1.2 Combustion Air Intake. A combustion air intake to draw air from the outside of the building directly into the firebox, which is an area of not less than 6 square inches (0.004 m²) and is equipped with a readily accessible, operable, and tight-fitting damper or combustion-air control device.

E 602.1.1.3 Accessible Damper Control. The flue damper shall have a readily accessible control.

Exception: Where a gas log, log lighter, or decorative gas appliance is installed in a fireplace, the flue damper shall be blocked open where required by this code or the manufacturer’s installation instructions.

E 602.1.2 Prohibited. Continuous burning pilot lights and the use of indoor air for cooling a firebox jacket, where the indoor air is vented to the outside of the building, are prohibited.

E 603.0 Pollutant Control.
E 603.1 Indoor Air Quality During Construction. Indoor air quality of a building shall be maintained in accordance with Section E 603.1.1 through Section E 603.1.3.

E 603.1.1 Temporary Ventilation During Construction. Temporary ventilation during construction shall be provided in accordance with the following:

(1) Ventilation during construction shall be achieved through openings in the building shell using fans to produce not less than three air changes per hour.

(2) During dust-producing operations, the supply and return HVAC system openings shall be protected from dust in accordance with Section E 603.1.3.

(3) Where the building is occupied during demolition or construction, ventilation shall be provided in accordance with the Control Measures of the SMACNA IAQ Guidelines for Occupied Buildings Under Construction.

(4) The permanent HVAC system shall not be used during construction to condition and ventilate the building within the required temperature range for material and equipment installation. Where required, a supplemental HVAC system shall be used during construction, return air shall be equipped with filters with a minimum efficiency reporting value (MERV) of 8, in accordance with ASHRAE 52.2, or an average efficiency of 30 percent in accordance with ASHRAE 52.2. Before occupancy, filters shall be replaced with filters having a MERV 13 rating in accordance with Section E 603.3.

Exception: Embedded hydronics system shall be permitted to be used to condition the building during construction.

E 603.1.2 Indoor Air Quality After Construction. After construction ends and interior finishes are installed, flush-out the building to reduce contaminant concentrations by supplying a total outdoor air volume of 14 000 cubic feet per square foot (ft³/ft²) (4267.2 m³/m²) of occupiable building area. An internal temperature of not less

<table>
<thead>
<tr>
<th>FLOOR AREA (ft²)</th>
<th>BEDROOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>&lt;500</td>
<td>30</td>
</tr>
<tr>
<td>501-1000</td>
<td>45</td>
</tr>
<tr>
<td>1001-1500</td>
<td>60</td>
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<td>1501-2000</td>
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</tr>
<tr>
<td>2501-3000</td>
<td>105</td>
</tr>
<tr>
<td>3001-3500</td>
<td>120</td>
</tr>
<tr>
<td>3501-4000</td>
<td>135</td>
</tr>
<tr>
<td>4001-4500</td>
<td>150</td>
</tr>
<tr>
<td>4501-5000</td>
<td>165</td>
</tr>
</tbody>
</table>

For SI units: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.00047 m³/s

TABLE E 605.1.3.1
VENTILATION AIR REQUIREMENTS, (cubic foot per minute)
[ASHRAE 62.2: TABLE 4.1a]
than 60°F (16°C) and relative humidity not higher than 60 percent shall be maintained during the flush-out process. Occupancy shall begin on condition of 3500 ft³/ft² (1066.8 m³/m²) of building area, with the remaining 10,500 ft³/ft² (3200.4 m³/m²) being accomplished as soon as possible.

Exception: Other means of reducing the contaminant concentration levels shall be permitted where approved by the Authority Having Jurisdiction.

E 603.1.3 Covering of Duct Openings and Protection of Mechanical Equipment During Construction. At the time of rough installation, or during storage on the construction site and until final startup of the heating and cooling equipment, duct and other related air distribution component openings shall be covered with tape, plastic, sheet metal, or other methods acceptable to the enforcing agency to reduce the amount of dust or debris that collects in the system.

E 603.2 Isolation of Pollutant Sources. Rooms where activities produce hazardous fumes or chemicals, including commercial kitchens, garages, janitorial or laundry rooms, and copy or printing rooms, shall be exhausted and isolated from adjacent spaces in accordance with this code.

E 603.3 Filters. In mechanically ventilated buildings, particle filters, or air-cleaning devices shall be provided to clean outdoor and return air prior to its delivery to occupied spaces. The particle or air cleaner shall have a MERV of 13.

Exception: A filter or air cleaning device with a lower MERV value shall be permitted provided it is the highest value commercially available for the specific equipment that is installed.

E 603.4 Ozone Depletion and Global Warming Reductions. Installations of HVAC and refrigeration shall not contain CFCs and shall be in accordance with this code.

E 604.0 Indoor Moisture Control.
E 604.1 Rainwater Control. Roof drainage systems shall discharge to a place of disposal in accordance with the plumbing code. Storm water shall be directed away from the building.

E 605.0 Indoor Air Quality for Low-Rise Residential.
E 605.1 General. Rooms or occupied spaces within single-family homes and multifamily structures of three stories or less above grade shall be designed to have ventilation (outdoor) air for occupants in accordance with Section E 605.1.1 through Section E 605.1.3.2, or the applicable local code.

E 605.1.1 Natural Ventilation. Naturally ventilated spaces shall be permanently open to and within 20 feet (6096 mm) of operable wall or roof openings to the outdoors, the openable area of which is not less than 5 percent of the conditioned floor area of the naturally ventilated space. Where openings are covered with louvers or otherwise obstructed, openable area shall be based on the free unobstructed area through the opening.

E 605.1.1.1 Access to Operable Openings. The means to open required operable openings shall be readily accessible to building occupants where the space is occupied.

E 605.1.2 Mechanical Ventilation. Each space that is not naturally ventilated in accordance with Section E 605.1.1 shall be ventilated with a mechanical system capable of providing an outdoor air rate not less than 15 ft³/min (0.007 m³/s) per person times the expected number of occupants. Mechanical ventilation shall comply with this code.

E 605.1.3 Dwelling-Unit Ventilation. A Mechanical exhaust system, supply system, or combination thereof shall be installed to operate for each dwelling unit to provide continuous dwelling-unit ventilation with outdoor air rate not less than the rate specified in Section E 605.1.3.1. [ASHRAE 62.2:4.1.1]

E 605.1.3.1 Total Ventilation Rate. The total required ventilation rate (\(Q_{tot}\)) shall be as specified in Table E 605.1.3.1 or, alternatively, calculated in accordance with Equation E 605.1.3.1.

\[
Q_{tot} = 0.034 A_{floor} + 7.5(N_{br} + 1)
\]

Where:

- \(Q_{tot}\) = total required ventilation rate, cubic feet per minute (ft³/min)
- \(A_{floor}\) = dwelling unit square foot (ft²)
- \(N_{br}\) = number of bedrooms; not to be less than one

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 square foot = 0.0929 m²

Exceptions: Dwelling-unit mechanical ventilation systems shall not be required where the Authority Having Jurisdiction determines that window operation is a locally permissible method of providing ventilation and provided one or more of the following conditions is met:

1. The building has no mechanical cooling and is located in zone 1 or 2.
2. The building is thermally conditioned for human occupancy for less than 876 hours per year. [ASHRAE 62.2:4.1.1.1]

E 605.1.3.2 Effective Annual Average Infiltration Rate (\(Q_{inf}\)). Effective Annual Average Infiltration Rate (\(Q_{inf}\)) shall be calculated using Equation E 605.1.3.2:

\[
Q_{inf} (\text{cfm}) = (NL \times wsf \times A_{floor}) / (7.3) *
\]

Where:

- \(NL\) = normalized leakage
- \(wsf\) = weather and shielding factor from ASHRAE 62.2.
- \(A_{floor}\) = floor area of residence, ft² (m²)

* Replace 7.3 with 1.44 for metric units. [ASHRAE 62.2:4.1.2(e)]
E 605.1.3.3 Required Mechanical Ventilation Rate ($Q_{fan}$). Required Mechanical Ventilation Rate ($Q_{fan}$) shall be calculated using Equation E 605.1.3.3:

$$Q_{fan} = Q_{tot} - (Q_{inf} \times A_{ext}) \quad \text{[Equation E 605.1.3.3]}$$

Where:

- $Q_{fan}$ = required mechanical ventilation rate, cfm (L/s)
- $Q_{tot}$ = total required ventilation rate, cfm (L/s)
- $Q_{inf}$ = may be not greater than $2/3 \times Q_{tot}$ (see ASHRAE 62.2 for exceptions for existing buildings)
- $A_{ext}$ = 1 for single-family detached homes, or the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to total envelope surface area for single-family attached homes. [ASHRAE 62.2.4.1.2(1)]

E 605.1.3.4 Different Occupant Density. Table E 605.1.3.1 and Equation E 605.1.3.1 assume two persons in a studio or one-bedroom dwelling unit and an additional person for each additional bedroom. Where higher occupant densities are known, the rate shall be increased by 7.5 ft³/min (0.003 m³/s) for each additional person. Where approved by the Authority Having Jurisdiction, lower occupant densities shall be permitted to be used. [ASHRAE 62.2.4.1.3]

E 605.1.4 System Type. The dwelling-unit mechanical ventilation system shall consist of one or more supply or exhaust fans and associated ducts and controls. Local exhaust fans shall be permitted to be part of a mechanical exhaust system. Where local exhaust fans are used to provide dwelling-unit ventilation, the local exhaust airflow shall be permitted to be credited towards the whole dwelling-unit ventilation airflow requirement. Outdoor air ducts connected to the return side of an air handler shall be permitted as supply ventilation where manufacturer’s requirements for return air temperature are met. See ASHRAE 62.2 for guidance on selection of methods. [ASHRAE 62.2.4.2]

E 605.1.5 Airflow Measurement. The airflow required by this section shall be the quantity of outdoor ventilation air supply, indoor air, or both exhausted by the mechanical ventilation system as installed and shall be measured according to the ventilation equipment manufacturer’s instructions, or by using a flow hood, flow grid, or other airflow measuring device at the mechanical ventilation fan’s inlet terminals/grilles, outlet terminals/grilles, or in the connected ventilation ducts. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to be in accordance with this section. [ASHRAE 62.2.4.3]

E 605.1.6 Control and Operation. A readily accessible manual ON-OFF control, including but not limited to a fan switch or a dedicated branch-circuit overcurrent device, shall be provided. Controls shall include text or an icon indicating the system’s function.

Exception: For multifamily dwelling units, the manual ON-OFF control shall not be required to be readily accessible. [ASHRAE 62.2.4.4]

E 605.1.7 Variable Mechanical Ventilation. Dwelling-unit mechanical ventilation systems designed to provide variable ventilation shall comply with Section E 605.1.7.1 or Section E 605.1.7.2 or Section E 605.1.7.3. Section E 605.1.7.2 and Section E 605.1.7.3 also require compliance with ASHRAE 62.2 and require verification with supporting documentation from the manufacturer, designer, or specifier of the ventilation control system that the system meets the requirements of these sections. Where the dwelling-unit ventilation rate varies based on occupancy, occupancy shall be determined by occupancy sensors or by an occupant-programmable schedule. [ASHRAE 62.2.4.5]

E 605.1.7.1 Short-Term Average Ventilation. To comply with this section, a variable ventilation system shall be installed to provide an average dwelling-unit ventilation rate over any three-hour period that is greater than or equal to $Q_{fan}$ as determined in accordance with Section E 605.1.3.3. [ASHRAE 62.2.4.5.1]

E 605.1.7.2 Scheduled Ventilation. This section shall only be allowed to be used where one or more fixed patterns of designed ventilation are known at the time compliance to Section E 605.0 is being determined. Such patterns include those both clock-driven and driven by typical meteorological data. Compliance with this section shall be in accordance with either Section E 605.1.7.2.1 or Section E 605.1.7.2.2. [ASHRAE 62.2.4.5.2]

E 605.1.7.2.1 Annual Average Schedule. An annual schedule of ventilation complies with this section when the annual average relative exposure during occupied periods is not more than unity as calculated in accordance with ASHRAE 62.2. [ASHRAE 62.2.4.5.2.1]

E 605.1.7.2.2 Block Scheduling. The schedule of ventilation complies with this section when it is broken into blocks of time and each block individually has an average relative exposure during occupied periods that is not more than unity as calculated in ASHRAE 62.2. [ASHRAE 62.2.4.5.2.2]

E 605.1.7.3 Real-Time Control. A real-time ventilation controller complies with this section when it is designed to adjust the ventilation system based on real-time input to the ventilation calculations so that the average relative exposure during occupied periods is not more than unity as calculated in ASHRAE 62.2. The averaging period shall be not less than one day but not more than one year and shall be based on simple, recursive or running average, but not extrapolation. [ASHRAE 62.2.4.5.3]
E 605.1.8 Equivalent Ventilation. A dwelling-unit ventilation system shall be designed and operated in such a way as to provide the same or lower annual exposure as would be provided in accordance with Section E 605.1.3. The calculations shall be based on a single zone with a constant contaminant emission rate. The manufacturer, specifier, or designer of the equivalent ventilation system shall certify that the system is in accordance with this intent and provide supporting documentation. [ASHRAE 62.2:4.6]

E 605.2 Bathroom Exhaust Fans. Except where a whole house energy recovery system is used, a mechanical exhaust fan vented to the outdoors shall be provided in each room containing a bathtub, shower, or tub/shower combination. The ventilation rate shall be not less than 50 ft³/min (0.02 m³/s) for intermittent operation and 20 ft³/min (0.009 m³/s) for continuous operation. Fans shall comply with the Energy Star Program.

E 605.3 Filters. Heating and air conditioning filters shall have a MERV rating of 6 or higher. The air distribution system shall be designed for the pressure drop across the filter.

E 606.0 Indoor Air Quality for Other than Low-Rise Residential Buildings.

E 606.1 Minimum Indoor Air Quality. The building shall comply with this code and ASHRAE 62.1 for ventilation air supply.

E 607.0 Environmental Comfort.

E 607.1 Thermal Comfort Controls. The mechanical systems and controls of building shall be designed to provide and maintain indoor comfort conditions in accordance with ASHRAE 55.

E 607.2 Heating and Air-Conditioning System Design. Heating and air-conditioning systems shall be sized, designed, and have their equipment selected in accordance with the following:

(1) Heat loss and heat gain are established in accordance with ACCA Manual J, ASHRAE handbooks, or other equivalent methods.
(2) Duct systems shall be sized in accordance with ACCA Manual D, ASHRAE handbooks, or other equivalent methods.
(3) Heating and cooling equipment in accordance with ACCA Manual S or other equivalent methods.

E 608.0 Low VOC Solvent Cement and Primer.

E 608.1 General. Primers and solvent cements used to join plastic pipe, and fittings shall be in accordance with Section E 608.1.1 and Section E 608.1.2.

E 608.1.1 Solvent Cement. Solvent cement, including one-step solvent cement, shall have a volatile organic compound (VOC) content of less than or equal to 65 ounces per gallon (oz/gal) (487 g/L) for CPVC cement, 68 oz/gal (509 g/L) for PVC cement, and 43 oz/gal (322 g/L) for ABS cement, as determined by the South Coast Air Quality Management District’s Laboratory Methods of Analysis for Enforcement Samples, Method 316A.

E 608.1.2 Primer. Primer shall have a volatile organic compound (VOC) content of less than or equal to 73 oz/gal (546 g/L), as determined by the South Coast Air Quality Management District’s Laboratory Methods of Analysis for Enforcement Samples, Method 316A.

E 701.0 Installer Qualifications.

E 701.1 Scope. The provisions of this section address minimum qualifications of installers of mechanical systems covered within the scope of this appendix.

E 702.0 Qualifications.

E 702.1 General. 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.

Part I

E 801.0 Heating, Ventilation, and Air Conditioning Systems Commissioning.

E 801.1 Applicability. The provisions of this section apply to the commissioning of commercial and institutional HVAC systems.

E 802.0 Commissioning.

E 802.1 Commissioning Requirements. HVAC commissioning shall be included in the design and construction processes of the project to verify that the HVAC systems and components meet the owner’s project requirements and in accordance with this appendix. 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 802.2 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 O&M personnel expectations

E 802.3 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 802.4 Commissioning Plan. A commissioning plan shall be completed to document the approach to 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 not less than the following:
   (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 802.5 through Section E 802.7 shall be included.

E 802.5 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 802.6 Post Construction Documentation and Training. A system manual and systems operations training are required.

E 802.6.1 Systems Manual. Documentation of the operational aspects of the HVAC system shall be completed within the systems manual and delivered to the building owner and facilities operator. The systems manual shall include not less than the following:
(1) Site information, including facility description, history, and current requirements.
(2) Site contact information.
(3) Basic O&M, including general site operating procedures, basic troubleshooting, recommended maintenance requirements, and site events log.
(4) Major systems.
(5) Site equipment inventory and maintenance notes.
(6) Equipment/system warranty documentation and information.
(7) "As-Built" design drawings.
(8) Other resources and documentation.

E 802.6.2 Systems Operations Training. The training of the appropriate maintenance staff for each equipment type or system shall include not less than the following:
(1) System/Equipment overview (what it is, what it does, and what other systems or equipment it interfaces with).
(2) Review of the information in the systems manual.
(3) Review of the record drawings on the system/equipment.

E 802.7 Commissioning Report. A complete report of commissioning process activities undertaken through the design, construction, and post-construction phases of the building project shall be completed and provided to the owner.

Part II

E 803.0 Commissioning Acceptance.

E 803.1 General. Part II of this appendix provides a means of verifying the commissioning requirements of Section E 802.1. The activities specified in Part II of this appendix includes three aspects, as described as follows:
(1) Visual inspection of the equipment and installation.
(2) Review of the certification requirements.
(3) Functional tests of the systems and controls.

E 803.2 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 system, 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 803.2.1 Roles and Responsibilities. The roles and responsibilities of the persons involved in commissioning acceptance are included in Section E 803.2.1.1 through Section E 803.2.1.3.

E 803.2.1.1 Field Technician. The field technician shall be responsible for performing and documenting the results of the acceptance procedures on the certificate of acceptance forms. The field tech-
 Demand-controlled ventilation control systems (Form MECH-6A).

(6) Supply fan variable flow controls (Form MECH-7A).

(7) Valve leakage for hydronic variable flow systems and isolation valves on chillers and boilers in plants with more than one chiller or boiler being served by the same primary pumps through a common header (Form MECH-8A).

(8) Supply water temperature reset control strategies programmed into the building automation system for water systems (e.g., chilled, hot, or condenser water) (Form MECH-9A).

(9) Hydronic variable flow controls on a water system where the pumps are controlled by variable frequency drives (e.g., chilled and hot water systems; water-loop heat pump systems) (Form MECH-10A).

(10) Automatic demand shed control (Form MECH-11A)

(11) Fault detection and diagnostic for DX units (Form MECH-12A).

(12) Automatic fault detection and diagnostic systems (AFDD) (Form MECH-13A).

(13) Distributed energy storage DEC/DX AC systems (Form MECH-14A).

(14) Thermal energy storage (TES) systems (Form MECH-15A).

E 804.3 Acceptance Process. The functional testing process shall comply with Section E 804.3.1 through Section E 804.3.4.

E 804.3.1 Plan Review. The installing contractor, registered design professional of record, owner’s agent, or the person responsible for certification of the acceptance testing on the certificate of acceptance (responsible person) shall review the plans and specifications to ensure that they are in accordance with the acceptance requirements. This is typically done prior to signing a certificate of compliance.

E 804.3.2 Construction Inspection. The installing contractor, registered design professional of record, owner’s agent, or the person responsible for certification of the acceptance testing on the certificate of acceptance (responsible person) shall perform a construction inspection prior to testing to ensure that the equipment that is installed is capable of complying with the requirements of this appendix and is calibrated. The installation of associated systems and equipment necessary for proper system operation is required to be completed prior to the testing.

E 804.3.3 Acceptance Testing. One or more field technicians shall perform the acceptance testing; identify performance deficiencies; ensure that they are corrected; and where necessary, repeat the acceptance procedures until the specified systems and equipment are performing in accordance with the acceptance requirements. The field technician who performs the testing shall sign the certificate of acceptance to certify the information has been provided to document the results of the acceptance procedures is true and correct.

The responsible person shall review the test results from the acceptance requirement procedures provided by

E 804.0 Commissioning Tests.

E 804.1 General. Functional tests shall be performed on new equipment and systems installed in either new construction or retrofit applications in accordance with this section. 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 804.2 Tests. Functional testing shall be performed on the devices and systems listed in this section. The functional test results are documented using the applicable certificate of acceptance forms shown in parenthesis and located in Section E 806.0. The functional tests shall be performed in accordance with Section E 805.0 using the following forms:

(1) Minimum ventilation controls for constant and variable air volume systems (Form MECH-2A).

(2) Zone temperature and scheduling controls for constant volume, single-zone, unitary air conditioner and heat pump systems (Form MECH-3A).

(3) Duct leakage on a subset of small single-zone systems depending on the ductwork location (Form MECH-4A).

(4) Air economizer controls for economizers that are not factory installed and tested (Form MECH-5A).

(5) Demand-controlled ventilation control systems (Form MECH-6A).
the field technician and sign the certificate of acceptance to certify compliance with the acceptance requirements. The responsible person shall be permitted to perform the field technician’s responsibilities, and shall then sign the field technician declaration on the certificate of acceptance to certify that the information on the form is true and correct.

**E 804.3.4 Certificate of Occupancy.** The Authority Having Jurisdiction shall not issue the final certificate of occupancy until required certificates of acceptance are submitted. Copies of completed, signed certificates of acceptance are required to be posted, or made available with the permit(s), and shall be made available to the Authority Having Jurisdiction.

**E 805.0 HVAC System Tests.**

**E 805.1 Variable Air Volume Systems (Form MECH-2A).** This test ensures that adequate outdoor ventilation is provided through the variable air volume air handling unit at two representative operating conditions. The test consists of measuring outdoor air values at maximum flow and at near minimum flow. The test verifies that the minimum volume of outdoor air is introduced to the air handling unit where the system is in occupied mode at these two conditions of supply airflow. This test shall be performed in conjunction with supply fan variable flow controls test procedures to reduce the overall system testing time as both tests use the same two conditions of airflow for their measurements.

**E 805.1.1 Test Procedure.** The procedure for performing a functional test for variable air volume systems shall be in accordance with Section E 805.1.1.1 and Section E 805.1.1.2.

**E 805.1.1.1 Construction Inspection.** Prior to functional testing, verify and document that the system controlling outside airflow is calibrated either in the field or factory.

**E 805.1.1.2 Functional Testing.** The functional testing shall be in accordance with the following steps:

- **Step 1:** Where the system has an outdoor air economizer, force the economizer high limit to disable economizer control (e.g., for a fixed drybulb high limit, lower the setpoint below the current outdoor air temperature).
- **Step 2:** Adjust supply airflow to either the sum of the minimum zone airflow(s) or 30 percent of the total design airflow. Verify and document the following:
  1. Measured outdoor airflow reading is within 10 percent of the total ventilation air called for in the certificate of compliance.
  2. OSA controls stabilize within 5 minutes.
- **Step 3:** Adjust supply airflow to achieve design airflow. Verify and document the following:
  1. Measured outdoor airflow reading is within 10 percent of the total ventilation air called for in the certificate of compliance.
  2. OSA controls stabilize within 5 minutes.
- **Step 4:** Restore system to “as-found” operating conditions.

**E 805.1.2 Acceptance Criteria.** System controlling outdoor air flow shall be calibrated in the field or at the factory.

Measured outdoor airflow reading shall be within 10 percent of the total value found on the certificate of compliance under the following conditions:

1. Minimum system airflow.
2. Thirty percent of total design flow design supply airflow.

**E 805.2 Constant Volume Systems (Form MECH-2A).**

The purpose of this test is to ensure that adequate outdoor air ventilation is provided through the constant volume air handling unit to the spaces served under operating conditions. The intent of this test is to verify that the minimum volume of outdoor air is introduced to the air handling unit during typical space occupancy.

**E 805.2.1 Test Procedure.** The procedure for performing a functional test for constant volume air systems shall be in accordance with Section E 805.2.1.1 and Section E 805.2.1.2.

**E 805.2.1.1 Construction Inspection.** Prior to functional testing, verify and document the following:

1. Minimum position is marked on the outside air damper.
2. The system has means of maintaining the minimum outdoor air damper position.

**E 805.2.1.2 Functional Testing.** Where the system has an outdoor air economizer, force the economizer to the minimum position and stop outside air damper modulation (e.g., for a fixed drybulb high limit, lower the setpoint below the current outdoor air temperature).

**E 805.2.2 Acceptance Criteria.** The system has a means of maintaining the minimum outdoor air damper position. The minimum damper position is marked on the outdoor air damper. The measured outdoor airflow reading shall be within 10 percent of the total ventilation air called for in the certificate of compliance.

**E 805.3 Constant Volume, Single-Zone, Unitary Air Conditioner and Heat Pumps Systems Acceptance (Form MECH-3A).** The purpose of this test is to verify the individual components of a constant volume, single-zone, unitary air conditioner and heat pump system function correctly, including: thermostat installation and programming, supply fan, heating, cooling, and damper operation.

**E 805.3.1 Test Procedure.** The procedure for performing a functional test for constant volume, single-zone, unitary air conditioner and heat pump systems shall be in accordance with Section E 805.3.1.1 and Section E 805.3.1.2.

**E 805.3.1.1 Construction Inspection.** Prior to functional testing, verify and document the following:
Thermostat is located within the space-conditioning zone that is served by the HVAC system.

Thermostat shall be in accordance with temperature adjustment and dead band requirements.

Occupied, unoccupied, and holiday schedules shall be programmed per the facility’s schedule.

Preoccupancy purge is programmed.

**E 805.3.1.2 Functional Testing.** The functional testing shall be in accordance with the following steps:

**Step 1:** Disable economizer and demand control ventilation systems (where applicable).

**Step 2:** Simulate a heating demand during the occupied condition. Verify and document the following:

1. Supply fan operates continually.
2. The unit provides heating.
3. No cooling is provided by the unit.
4. Outside air damper is at minimum position.

**Step 3:** Simulate operation in the dead band during occupied condition. Verify and document the following:

1. Supply fan operates continually.
2. Neither heating nor cooling is provided by the unit.
3. Outside air damper is at minimum position.

**Step 4:** Simulate cooling demand during occupied condition. Lock out economizer (where applicable). Verify and document the following:

1. Supply fan operates continually.
2. The unit provides cooling.
3. No heating is provided by the unit.
4. Outside air damper is at minimum position.

**Step 5:** Simulate operation in the dead band during unoccupied mode. Verify and document the following:

1. Supply fan is off.
2. Outside air damper is fully closed.
3. Neither heating nor cooling is provided by the unit.

**Step 6:** Simulate heating demand during unoccupied conditions. Verify and document the following:

1. Supply fan is on (either continuously or cycling).
2. Heating is provided by the unit.
3. No cooling is provided by the unit.
4. Outside air damper is either closed or at minimum position.

**Step 7:** Simulate cooling demand during unoccupied condition. Lock out economizer (where applicable). Verify and document the following:

1. Supply fan is on (either continuously or cycling).
2. Cooling is provided by the unit.
3. No heating is provided by the unit.
4. Outside air damper is either closed or at minimum position.

**Step 8:** Simulate manual override during unoccupied condition. Verify and document the following:

1. System operates in “occupied” mode.
2. System reverts to “unoccupied” mode when manual override time period expires.

**Step 9:** Restore economizer and demand control ventilation systems (where applicable), and remove system overrides initiated during the test.

**E 805.3.2 Acceptance Criteria.** Thermostat is located within the space-conditioning zone that is served by the respective HVAC system. The thermostat shall comply with temperature adjustment and dead band requirements. Occupied, unoccupied, and holiday schedules shall be programmed per the facility’s schedule. Preoccupancy purge is programmed in accordance with the requirements.

**E 805.4 Air Distribution Systems (Form MECH-4A).** The purpose of this test is to verify duct work associated with non-exempt constant volume, single-zone, HVAC units (e.g., air conditioners, heat pumps, and furnaces) meet the material, installation, and insulation R-values and leakage requirements outlined in this appendix. This test is required for single-zone units serving less than 5000 square feet (464.52 m²) of floor area where 25 percent or more of the duct surface area is in one of the following spaces:

1. Outdoors.
2. In a space directly under a roof where the U-factor of the roof is greater than the U-factor of the ceiling.
3. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces.
4. In an unconditioned crawl space.
5. In other unconditioned spaces.

This test applies to both new duct systems and to existing duct systems being extended or the space conditioning system is altered by the installation or replacement of space conditioning equipment, including: replacement of the air handler; outdoor condensing unit of a split system air conditioner or heat pump; cooling or heating coil; or the furnace heat exchanger. Existing duct systems do not have to be tested where they are insulated or sealed with asbestos.

**E 805.4.1 Test Procedure.** The procedure for performing a functional test for air distribution systems shall be in accordance with Section E 805.4.1.1 and Section E 805.4.1.2.

**E 805.4.1.1 Construction Inspection.** Prior to functional testing, verify and document the following:

1. Duct connections shall comply with the requirements of this appendix and this code.
(2) Flexible ducts are not compressed.
(3) Ducts are fully accessible for testing.
(4) Joints and seams are properly sealed in accordance with the requirements of this appendix.
(5) Insulation R-Values shall comply with the minimum requirements of this appendix.

E 805.4.1.2 Functional Testing. Perform duct leakage test in accordance with Section E 503.4.7.2.1.

E 805.4.2 Acceptance Criteria. Flexible ducts are not compressed or constricted. Duct connections shall comply with the requirements of this appendix and this code (new ducts only). Joints and seams are properly sealed in accordance with the requirements of this appendix and this code (new ducts only). Duct R-values shall comply with the minimum requirements of this appendix (new ducts only). Insulation is protected from damage and suitable for outdoor usage where applicable (new ducts only). The leakage shall not exceed the rate in accordance with Section E 503.4.7.2.

E 805.5 Air Economizer Controls Acceptance (Form MECH-5A). The purpose of functionally testing an air economizer cycle is to verify that an HVAC system uses outdoor air to satisfy space cooling loads where outdoor air conditions are acceptable. There are two types of economizer controls; stand-alone packages and DDC controls. The stand-alone packages are commonly associated with small unitary rooftop HVAC equipment, and DDC controls are typically associated with built-up or large packaged air handling systems. Test procedures for both economizer control types are provided.

E 805.5.1 Test Procedure. The procedure for performing a functional test for air economizer controls shall comply with Section E 805.5.1.1 and Section E 805.5.1.2.

E 805.5.1.1 Construction Inspection. Prior to functional testing, verify and document the following:

(1) Economizer lockout setpoint is in accordance with this appendix.
(2) Economizer lockout control sensor is located to prevent false readings.
(3) System is designed to provide up to 100 percent outside air without over-pressurizing the building.
(4) For systems with DDC controls lockout sensor(s) are either factory calibrated or field calibrated.
(5) For systems with non-DDC controls, manufacturer’s startup and testing procedures are applied.

E 805.5.1.2 Functional Testing. The functional testing shall be in accordance with the following steps:

Step 1: Disable demand control ventilation systems (where applicable).
Step 2: Enable the economizer, and simulate a cooling demand large enough to drive the economizer fully open. Verify and document the following:

(1) Economizer damper is 100 percent opened and return air damper is 100 percent closed.
(2) Where applicable, verify that the economizer remains 100 percent open where the cooling demand can no longer be met by the economizer alone.
(3) Applicable fans and dampers operate as intended to maintain building pressure.
(4) The unit heating is disabled.

Step 3: Disable the economizer and simulate a cooling demand. Verify and document the following:

(1) Economizer damper shall close to its minimum position.
(2) Applicable fans and dampers operate as intended to maintain building pressure.
(3) The unit heating is disabled.

Step 4: Simulate a heating demand, and set the economizer so that it is capable of operating (e.g., actual outdoor air conditions are below lockout setpoint). Verify the economizer is at minimum position.
Step 5: Restore demand control ventilation systems (where applicable) and remove system overrides initiated during the test.

E 805.5.2 Acceptance Criteria. Air economizer controls acceptance criteria shall be as follows:

(1) Where the economizer is factory installed and certified, a valid factory certificate is required for acceptance. No additional equipment tests are necessary.
(2) Air economizer lockout setpoint is in accordance with this appendix. Outside sensor location accurately reads true outdoor air temperature and is not affected by exhaust air or other heat sources.
(3) Sensors are located to achieve the desired control.
(4) During economizer mode, the outdoor air damper shall modulate open to a maximum position and return air damper to 100 percent closed.
(5) The outdoor air damper is 100 percent open before mechanical cooling is enabled and for units 75 000 Btu/h (22 kw) and larger remains at 100 percent open while mechanical cooling is enabled (economizer integration where used for compliance).
(6) Where the economizer is disabled, the outdoor air damper closes to a minimum position; the return damper modulates 100 percent open, and mechanical cooling remains enabled.
**E 805.6 Demand-Controlled Ventilation Systems**

**Acceptance (Form MECH-6A).** The purpose of this test is to verify that systems required to employ demand-controlled ventilation shall be permitted to vary outside ventilation flow rates based on maintaining interior carbon dioxide (CO₂) concentration setpoints. Demand-controlled ventilation refers to an HVAC system's ability to reduce outdoor air ventilation flow below design values where the space served is at less than design occupancy. Carbon dioxide is a good indicator of occupancy load and is the basis used for modulating ventilation flow rates.

**E 805.6.1 Test Procedure.** The procedure for performing a functional test for demand-control ventilation (DVC) systems shall be in accordance with Section E 805.6.1.1 and Section E 805.6.1.2.

**E 805.6.1.1 Construction Inspection.** Prior to functional testing, verify and document the following:

1. Carbon dioxide control sensor is factory calibrated or field-calibrated in accordance with this appendix.
2. The sensor is located in the high-density space between 3 feet (914 mm) and 6 feet (1829 mm) above the floor or at the anticipated level of the occupants' heads.
3. DCV control setpoint is at or below the carbon dioxide concentration permitted by this appendix.

**E 805.6.1.2 Functional Testing.** The functional testing shall be in accordance with the following steps:

**Step 1:** Disable economizer controls.

**Step 2:** Simulate a signal at or slightly above the carbon dioxide concentration setpoint required by this appendix. Verify and document the following:

1. For single zone units, outdoor air damper modulates open to satisfy the total ventilation air called for in the certificate of compliance.
2. For multiple zone units, either outdoor air damper or zone damper modulate open to satisfy the zone ventilation requirements.

**Step 3:** Simulate signal well below the carbon dioxide setpoint. Verify and document the following:

1. For single zone units, outdoor air damper modulates to the design minimum value.
2. For multiple zone units, either outdoor air damper or zone damper modulate open to satisfy the reduced zone ventilation requirements.

**Step 4:** Restore economizer controls and remove system overrides initiated during the test.

**Step 5:** With controls restored, apply carbon dioxide calibration gas at a concentration slightly above the setpoint to the sensor. Verify that the outdoor air damper modulates open to satisfy the total ventilation air called for in the certificate of compliance.

**E 805.6.2 Acceptance Criteria.** Demand-controlled ventilation systems acceptance criteria shall be as follows:

1. Each carbon dioxide sensor is factory calibrated (with calibration certificate) or field calibrated.
2. Each carbon dioxide sensor is wired correctly to the controls to ensure proper control of the outdoor air damper.
3. Each carbon dioxide sensor is located correctly within the space 1 foot (305 mm) to 6 feet (1829 mm) above the floor.
4. Interior carbon dioxide concentration setpoint is not more than 600 parts per million (ppm) plus outdoor air carbon dioxide value where dynamically measured or not more than 1000 ppm where no OSA sensor is provided.
5. A minimum OSA setting is provided where the system is in occupied mode in accordance with this appendix regardless of space carbon dioxide readings.
6. A maximum OSA damper position for DCV control shall be established in accordance with this appendix, regardless of space carbon dioxide readings.
7. The outdoor air damper shall modulate open where the carbon dioxide concentration within the space exceeds setpoint.
8. The outdoor air damper modulates closed (toward minimum position) where the carbon dioxide concentration within the space is below setpoint.

**E 805.7 Supply Fan Variable Flow Controls (Form MECH-7A).** The purpose of this test is to ensure that the supply fan in a variable air volume application modulates to meet system airflow demand. In most applications, the individual VAV boxes serving each space will modulate the amount of air delivered to the space based on heating and cooling requirements. As a result, the total supply airflow provided by the central air handling unit shall vary to maintain sufficient airflow through each VAV box. Airflow shall be controlled using a variable frequency drive (VFD) to modulate supply fan speed and vary system airflow. The most common strategy for controlling the VFD is to measure and maintain static pressure within the duct.

**E 805.7.1 Test Procedure.** The procedure for performing a functional test for supply fan variable controls shall be in accordance with Section E 805.7.1.1 and Section E 805.7.1.2.

**E 805.7.1.1 Construction Inspection.** Prior to functional testing, verify and document the following:

1. Supply fan controls modulate to increase capacity.
2. Supply fan maintains discharge static pressure within plus or minus 10 percent of the current operating set point.
3. Supply fan controls stabilize within a 5 minute period.
E 805.7.1.2 Functional Testing. The functional testing shall be in accordance with the following steps:
Step 1: Simulate demand for design airflow. Verify and document the following:
1. Supply fan controls modulate to increase capacity.
2. Supply fan maintains discharge static pressure within plus or minus 10 percent of the current operating set point.
3. Supply fan controls stabilize within a 5 minute period.
Step 2: Simulate demand for minimum airflow. Verify and document the following:
1. Supply fan controls modulate to decrease capacity.
2. Current operating setpoint has decreased (for systems with DDC to the zone level).
3. Supply fan maintains discharge static pressure within plus or minus 10 percent of the current operating setpoint.
4. Supply fan controls stabilize within a 5 minute period.
Step 3: Restore system to correct operating conditions.
E 805.7.2 Acceptance Criteria. Supply fan variable flow controls acceptance criteria shall be as follows:
1. Static pressure sensor(s) is factory calibrated (with calibration certificate) or field calibrated.
2. For systems without DDC controls to the zone level, the pressure sensor setpoint is less than one-third of the supply fan design static pressure.
3. For systems with DDC controls with VAV boxes reporting to the central control panel, the pressure setpoint is reset by zone demand (box damper position or a trim and respond algorithm).
At full flow:
1. Supply fan maintains discharge static pressure within plus or minus 10 percent of the current operating control static pressure setpoint.
2. Supply fan controls stabilizes within a 5 minute period.
3. At minimum flow (not less than 30 percent of total design flow).
4. Supply fan controls modulate to decrease capacity.
5. Current operating setpoint has decreased (for systems with DDC to the zone level).
6. Supply fan maintains discharge static pressure within plus or minus 10 percent of the current operating setpoint.
E 805.8 Valve Leakage (Form MECH-8A). The purpose of this test is to ensure that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation. Valves with insufficient actuators will lift under certain conditions causing water to leak through and loss of control. This test applies to the variable flow systems, chilled and hot-water variable flow systems, chiller isolation valves, boiler isolation valves, and water-cooled air conditioner and hydronic heat pump systems.
E 805.8.1 Test Procedure. The procedure for performing a functional test for valve leakage shall be in accordance with Section E 805.8.1.1 and Section E 805.8.1.2.
E 805.8.1.1 Construction Inspection. Prior to functional testing, verify and document the valve and piping arrangements were installed in accordance with the design drawings.
E 805.8.1.2 Functional Testing. The functional testing shall be in accordance with the following steps:
Step 1: For each pump serving the distribution system, dead head the pumps using the discharge isolation valves at the pumps. Document the following:
1. Record the differential pressure across the pumps.
2. Verify that this is within 5 percent of the submittal data for the pump.
Step 2: Reopen the pump discharge isolation valves. Automatically close valves on the systems being tested. Where three-way valves are present, close off the bypass line. Verify and document the following:
1. The valves automatically close.
2. Record the pressure differential across the pump.
3. Verify that the pressure differential is within 5 percent of the reading from Step 1 for the pump that is operating during the valve test.
Step 3: Restore system to correct operating conditions.
E 805.8.2 Acceptance Criteria. System has no flow where coils are closed and the pump is turned on.
E 805.9 Supply Water Temperature Reset Controls (Form MECH-9A). The purpose of this test is to ensure that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences. Many HVAC systems are served by central chilled and heating hot water plants. The supply water operating temperatures shall meet peak loads where the system is operating at design conditions. As the loads vary, the supply water temperatures shall be permitted to be adjusted to satisfy the new operating conditions. The chilled water supply temperature shall be permitted to be raised as the cooling load decreases, and heating hot water supply temperature shall be permitted to be lowered as the heating load decreases.
This requirement applies to chilled and hot water systems that are not designed for variable flow, and that have a design capacity greater than or equal to 500 000 Btu/h (147 kW).
E 805.9.1 Test Procedure. The procedure for performing a functional test for supply water temperature reset controls shall be in accordance with Section E 805.9.1.1 and Section E 805.9.1.2.

E 805.9.1.1 Construction Inspection. Prior to functional testing, verify and document the supply water temperature sensors shall be either factory or field calibrated.

E 805.9.1.2 Functional Testing. The functional testing shall be in accordance with the following steps:

Step 1: Change reset control variable to its maximum value. Verify and document the following:

1. Chilled or hot water temperature setpoint is reset to appropriate value.
2. Actual supply temperature changes to meet setpoint.
3. Verify that supply temperature is within 2 percent of the control setpoint.

Step 2: Change reset control variable to its minimum value. Verify and document the following:

1. Chilled or hot water temperature setpoint is reset to appropriate value.
2. Actual supply temperature changes to meet setpoint.
3. Verify that supply temperature is within 2 percent of the control setpoint.

Step 3: Restore reset control variable to automatic control. Verify and document the following:

1. Chilled or hot water temperature setpoint is reset to appropriate value.
2. Actual supply temperature changes to meet setpoint.
3. Verify that supply temperature is within 2 percent of the control setpoint.

E 805.9.2 Acceptance Criteria. The supply water temperature sensors are either factory calibrated (with calibration certificates) or field-calibrated. Sensor performance shall comply with the specifications. The supply water reset is operational.

E 805.10 Hydronic System Variable Flow Controls (Form MECH-10A). The purpose of this test is to ensure that hydronic variable flow chilled water and water-loop heat pump systems with circulating pumps larger than 5 hp (3.7 kW) vary system flow rate by modulating pump speed using a variable frequency drive (VFD) or equivalent. As the loads within the building fluctuate, control valves modulate the amount of water passing through each coil and add or remove the desired amount of energy from the air stream to satisfy the load. In the case of water-loop heat pumps, each two-way control valve associated with a heat pump will be closed where that unit is not operating. As each control valve modulates, the pump variable frequency drive (VFD) responds accordingly to meet system water flow requirements. This is not required on heating hot water systems with variable flow designs or for condensing water serving water cooled chillers.

E 805.10.1 Test Procedure. The procedure for performing a functional test for hydronic system variable flow controls shall be in accordance with Section E 805.10.1.1 and Section E 805.10.1.2.

E 805.10.1.1 Construction Inspection. Prior to functional testing, verify and document the pressure sensors are either factory or field calibrated.

E 805.10.1.2 Functional Testing. The functional testing shall comply with the following steps:

Step 1: Engage the global demand shed system. Verify and document the following:

1. Pump speed increases.
2. System pressure is either within plus or minus 5 percent of current operating setpoint, or the pressure is below the setpoint, and the pumps are operating at 100 percent speed.

E 805.10.2 Acceptance Criteria. The differential pressure sensor is either factory calibrated (with calibration certificates) or field calibrated. The pressure sensor shall be located at or near the most remote HX or control valve. The setpoint system controls shall stabilize.

E 805.11 Automatic Demand Shed Control (Form MECH-11A). The purpose of this test is to ensure that the central demand shed sequences have been properly programmed into the DDC system.

E 805.11.1 Test Procedure. The procedure for performing a functional test for automatic demand shed controls shall be in accordance with Section E 805.11.1.1 and Section E 805.11.1.2.

E 805.11.1.1 Construction Inspection. Prior to functional testing, verify and document that the EMCS interface enables activation of the central demand shed controls.

E 805.11.1.2 Functional Testing. The functional testing shall comply with the following steps:

Step 1: Engage the global demand shed system. Verify and document the following:

1. That the cooling setpoint in noncritical spaces increases by the proper amount.
That the cooling setpoint in critical spaces do not change.

Step 2: Disengage the global demand shed system. Verify and document the following:
(1) That the cooling setpoint in noncritical spaces return to their original values.
(2) That the cooling setpoint in critical spaces do not change.

E 805.11.2 Acceptance Criteria. The control system changes the setpoints of noncritical zones on activation of a single central hardware or software point then restores the initial setpoints where the point is released.

E 805.12 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion (DX) Units (Form MECH-12A). The purpose of this test is to verify proper fault detection and reporting for automated fault detection and diagnostics systems for packaged units. Automated FDD systems ensure proper equipment operation by identifying and diagnosing common equipment problems such as improper refrigerant charge, low airflow, or faulty economizer operation. Qualifying FDD systems receive a compliance credit where using the performance approach. A system that does not meet the eligibility requirements shall be permitted to be installed, but no compliance credit will be given.

E 805.12.1 Test Procedure. The procedure for performing a functional test for fault detection and diagnostics (FDD) for packaged direct-expansion (DX) units shall be in accordance with Section E 805.12.1.1 and Section E 805.12.1.2.

E 805.12.1.1 Construction Inspection. Prior to functional testing, verify and document that the FDD hardware is installed on equipment by the manufacturer, and that equipment make and model include factory-installed FDD hardware that match the information indicated on copies of the manufacturer’s cut sheets and on the plans and specifications.

This procedure applies to fault detection and diagnostics (FDD) system for direct-expansion packaged units containing the following features:
(1) The unit shall include a factory-installed economizer and shall limit the economizer dead band to not more than 2°F (-17°C).
(2) The unit shall include direct-drive actuators on outside air and return air dampers.
(3) The unit shall include an integrated economizer with either differential drybulb or differential enthalpy control.
(4) The unit shall include a low temperature lock-out on the compressor to prevent coil freeze-up or comfort problems.
(5) Outside air and return air dampers shall have maximum leakage rates in accordance to this appendix.
(6) The unit shall have an adjustable expansion control device such as a thermostatic expansion valve (TXV).
(7) To improve the ability to troubleshoot charge and compressor operation, a high-pressure refrigerant port will be located on the liquid line. A low-pressure refrigerant port will be located on the suction line.
(8) The following sensors shall be permanently installed to monitor system operation, and the controller shall have the capability of displaying the value of each parameter:
(a) Refrigerant suction pressure
(b) Refrigerant suction temperature
(c) Liquid line pressure
(d) Liquid line temperature
(e) Outside air temperature
(f) Outside air relative humidity
(g) Return air temperature
(h) Return air relative humidity
(i) Supply air temperature
(j) Supply air relative humidity

The controller will provide system status by indicating the following conditions:
(1) Compressor enabled
(2) Economizer enabled
(3) Free cooling available
(4) Mixed air low limit cycle active
(5) Heating enabled

The unit controller shall have the capability to manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified.

E 805.12.2 Acceptance Criteria. The system is able to detect a low airflow condition and report the fault. The system is able to detect where refrigerant charge is low or high and the fault is reported.

E 805.13 Automatic Fault Detection Diagnostics (FDD) for Air Handling Units (AHU) and Zone Terminal Units (Form MECH-13A). The purpose of this test is to verify that the system detects common faults in air handling units and terminal units. FDD systems for air handling units and zone terminal units require DDC controls to the zone level. Successful completion of this test provides a com-
pliance credit where using the performance approach. An FDD system that does not pass this test shall be permitted to be installed, but no compliance credit will be given.

**E 805.13.1 Test Procedure.** The procedure for performing a functional test for automatic fault detection diagnostics (FDD) for Air Handling Units and Zone Terminal Units shall be in accordance with Section E 805.13.1.1.

**E 805.13.1.1 Functional Testing.** The functional testing shall be in accordance with Section E 805.13.1.1 and Section E 805.13.1.1.2.

**E 805.13.1.1.1 Functional Testing for Air Handling Units.** The functional testing of AHU with FDD controls shall be in accordance with the following steps:

**Step 1: Sensor drift/failure:**
1. Disconnect outside air temperature sensor from unit controller.
2. Verify that the FDD system reports a fault.
3. Connect OAT sensor to the unit controller.
4. Verify that FDD indicates normal system operation.

**Step 2: Damper/actuator fault:**
1. From the control system workstation, command the mixing box dampers to full open (100 percent outdoor air).
2. Disconnect power to the actuator and verify that a fault is reported at the control workstation.
3. Reconnect power to the actuator and command the mixing box dampers to full open.
4. Verify that the control system does not report a fault.

**Step 3: Valve/actuator fault:**
1. Command the mixing box dampers to a full-closed position (0 percent outdoor air).
2. Disconnect power to the actuator and verify that a fault is reported at the control workstation.
3. Reconnect power to the actuator and command the dampers closed.
4. Verify that the control system does not report a fault during normal operation.

**Step 3: Valve/actuator fault:**
1. From the control system workstation, command the heating and cooling coil valves to full open or closed, then disconnect power to the actuator and verify that a fault is reported at the control workstation.

**Step 4: Inappropriate simultaneous heating, mechanical cooling, and economizing or all functions:**
1. From the control system workstation, override the heating coil valve and verify that a fault is reported at the control workstation.

**Step 4:**
1. From the control system workstation, override the cooling coil valve and verify that a fault is reported at the control workstation.

2. From the control system workstation, override the mixing box dampers and verify that a fault is reported at the control workstation.

**E 805.13.1.1.2 Functional Testing for Zone Terminal Units.** The functional testing of one of each type of terminal unit (VAV box) in the project not less than 5 percent of the terminal boxes shall be in accordance with the following steps:

**Step 1: Sensor drift/failure:**
1. Disconnect the tubing to the differential pressure sensor of the VAV box.
2. Verify that control system detects and reports the fault.
3. Reconnect the sensor and verify proper sensor operation.
4. Verify that the control system does not report a fault.

**Step 2: Damper/actuator fault:**
1. Damper stuck open.
   a. Command the damper to full open (room temperature above setpoint).
   b. Disconnect the actuator to the damper.
   c. Adjust the cooling setpoint so that the room temperature is below the cooling setpoint to command the damper to the minimum position. Verify that the control system reports a fault.
   d. Reconnect the actuator and restore to normal operation.

2. Damper stuck closed.
   a. Set the damper to the minimum position.
   b. Disconnect the actuator to the damper.
   c. Set the cooling setpoint below the room temperature to simulate a call for cooling. Verify that the control system reports a fault.
   d. Reconnect the actuator and restore to normal operation.

**Step 3: Valve/actuator fault (for systems with hydronic reheat):**
1. Command the reheat coil valve to full open.
2. Disconnect power to the actuator. Set the heating setpoint temperature to be lower than the current space temperature, to command the valve closed. Verify that the fault is reported at the control workstation.
3. Reconnect the actuator and restore to normal operation.

**Step 3:**
1. Command the reheat coil valve to full open.
2. Disconnect power to the actuator. Set the heating setpoint temperature to be lower than the current space temperature, to command the valve closed. Verify that the fault is reported at the control workstation.
(3) Reconnect the actuator and restore normal operation.

Step 4: Feedback loop tuning fault (unstable airflow):

(1) Set the integral coefficient of the box controller to a value 50 times the current value.
(2) The damper cycles continuously and airflow is unstable. Verify that the control system detects and reports the fault.
(3) Reset the integral coefficient of the controller to the original value to restore normal operation.

Step 5: Disconnected inlet duct:

(1) From the control system workstation, command the damper to full closed; then disconnect power to the actuator, and verify that a fault is reported at the control workstation.

E 805.13.2 Acceptance Criteria. The system is able to detect common faults with air-handling units, such as a sensor failure, a failed damper, an actuator, or an improper operating mode.

The system is able to detect and report common faults with zone terminal units, such as a failed damper, an actuator, or a control tuning issue.

E 805.14 Distributed Energy Storage DX AC System (Form MECH-14A). The purpose of this test is to verify the proper operation of distributed energy storage DX systems. Distributed energy systems (DES) reduce peak demand by operating during off-peak hours and storing cooling, usually in the form of ice. During peak cooling hours the ice is melted to avoid compressor operation. The system typically consists of a water tank containing refrigerant coils that cool the water and convert it to ice. As with a standard direction expansion (DX) air conditioner, the refrigerant is compressed in a compressor and then cooled in an air-cooled condenser. The liquid refrigerant then is directed through the coils in the water tank to make ice or to air handler coils to cool the building. This applies to constant or variable volume, direct expansion (DX) systems with distributed energy storage (DES/DXAC).

E 805.14.1 Test Procedure. The procedure for performing a functional test for distributed energy storage DX AC systems shall be in accordance with Section E 805.14.1.1 through Section E 805.14.1.3.

E 805.14.1.1 Construction Inspection. Prior to functional testing, verify and document the following:

(1) The water tank is filled to the proper level.
(2) The water tank is sitting on a foundation with adequate structural strength.
(3) The water tank is insulated and the top cover is in place.
(4) The DES/DXAC is installed correctly (e.g., refrigerant piping, etc.).
(5) Verify that the correct model number is installed and configured.

E 805.14.1.2 Functional Testing. The functional testing shall be in accordance with the following steps:

Step 1: Simulate cooling load during daytime period (e.g., by setting time schedule to include actual time and placing thermostat cooling setpoint below actual temperature). Verify and document the following:

(1) Supply fan operates continually.
(2) Where the DES/DXAC has cooling capacity, DES/DXAC shall run to meet the cooling demand (in ice melt mode).
(3) Where the DES/DXAC has no ice and there is a call for cooling, the DES/DXAC shall run in direct cooling mode.

Step 2: Simulate no cooling load during daytime condition. Verify and document the following:

(1) Supply fan operates in accordance with the facility thermostat or control system.
(2) The DES/DXAC and the condensing unit do not run.

Step 3: Simulate no cooling load during morning shoulder time period. Verify and document the following:

(1) The DES/DXAC is idle.
(2) The DES/DXAC runs in direct cooling mode.

E 805.14.1.3 Calibrating Controls. Set the proper time and date in accordance with the manufacturer’s instructions for approved installers.

E 805.14.2 Acceptance Criteria. Distributed energy storage DXAC system acceptance criteria shall be as follows:

(1) Verify night time ice making operation.
(2) Verify that tank discharges during on-peak cooling periods.
(3) Verify that the compressor does not run and the tank does not discharge where there is no cooling demand during on-peak periods.
(4) Verify that the system does not operate during a morning shoulder period where there is no cooling demand.
(5) Verify that the system operates in direct mode (with compressor running) during the morning shoulder time period.

E 805.15 Thermal Energy Storage (TES) System (Form MECH-15A). The purpose of this test is to verify the proper operation of thermal energy storage (TES) systems. TES systems reduce energy consumption during peak demand periods by shifting energy consumption to nighttime. Operation of the thermal energy storage compressor during the night produces cooling energy which is stored in the form
of cooled fluid or ice in tanks. During peak cooling hours the thermal storage is used for cooling to prevent the need for chiller operation. This section is limited to the following types of TES systems:

1. Chilled water storage
2. Ice-on-coil
3. Ice harvester
4. Brine
5. Ice-slurry
6. Eutectic salt
7. Clathrate hydrate slurry (CHS)

**E 805.15.1 Test Procedure.** The procedure for performing a functional test for thermal energy storage (TES) system shall be in accordance with Section E 805.15.1.1 and Section E 805.15.1.2.

**E 805.15.1.1 Construction Inspection.** Prior to functional testing, verify and document the following for the chiller and storage tank:

1. Chiller:
   a. Brand and Model
   b. Type (centrifugal, reciprocating, other)
   c. Capacity (tons) (SIZE)
   d. Starting efficiency (kW/ton) at beginning of ice production (COMP - kW/TON - START)
   e. Ending efficiency (kW/ton) at end of ice production (COMP - kW/TON/END)
   f. Capacity reduction (percent/°F) (PER – COMP - REDUCT/F)
   g. Verify that the efficiency of the chiller meets or exceeds the requirements of Section E 501.0.

2. Storage Tank:
   a. Storage type (TES-TYPE)
   b. Number of tanks (SIZE)
   c. Storage capacity per tank (ton-hours) (SIZE)
   d. Storage rate (tons) (COOL – STORE - RATE)
   e. Discharge rate (tons) (COOL – SUPPLY - RATE)
   f. Auxiliary power (watts) (PUMPS + AUX - kW)
   g. Tank area (CTANK – LOSS - COEFF)
   h. Tank insulation (R-Value) (CTANK – LOSS – COEFF)

3. TES System:
   a. The TES system is one of the above eligible systems.
   b. Initial charge rate of the storage tanks (tons).
   c. Final charge rate of the storage tank (tons).
   d. Initial discharge rate of the storage tanks (tons).
   e. Final discharge rate of the storage tank (tons).
   f. Charge test time (hrs).
   g. Discharge test time (hrs).
   h. Tank storage capacity after charge (ton-hrs).
   i. Tank storage capacity after discharge (ton-hrs).
   j. Tank standby storage losses (UA).
   k. Initial chiller efficiency (kW/ton) during charging.
   l. Final chiller efficiency (kW/ton) during charging.

**E 805.15.1.2 Functional Testing.** The functional testing shall be in accordance with the following steps:

Step 1: Verify that the TES system and the chilled water plant is controlled and monitored by an energy management system (EMS).

Step 2: Force the time to be between 9:00 p.m. and 9:00 a.m., and simulate a partial or no charge of the tank. Simulate no cooling load by setting the indoor temperature setpoint(s) higher than the ambient temperature.

Where the tank is full or nearly full of ice, it shall be permitted to adjust the control settings for this test. In some cases, the control system will not permit the chiller to start the ice-making process unless a portion of the ice has been melted. The controls designer shall be permitted to use an inventory meter (a 4-20 mA sensor that indicates water level) to determine whether or not ice-making can commence (e.g., not allow ice-making unless the inventory meter signal is less than 17 mA). Where this is the case, this limit can be reset to 20 mA during testing to allow ice making to occur.

Verify that the TES system starts charging (storing energy). This shall be checked by verifying flow and inlet and outlet temperatures of the storage tank, or directly by reading an inventory meter where the system has one.

Step 3: Force the time to be between 6:00 p.m. and 9:00 p.m., and simulate a partial charge on the tank. Simulate a cooling load by setting the indoor temperature setpoint lower than the ambient temperature. Verify that the TES system starts discharging. This shall be checked by observing tank inlet and outlet temperatures and system flow, or directly by reading an inventory meter where the system has one. Where the system has no charge, verify that the system will still attempt to meet the load through storage.

Step 4: Force the time to be between noon and 6:00 p.m., and simulate a cooling load by lowering the
Step 5: Force the time to be between 9:00 a.m. to noon, and simulate a cooling load by lowering the indoor air temperature setpoint below the ambient temperature. Verify that the tank does not discharge and the cooling load is met by the compressor.

Step 6: Force the time to be between 9:00 p.m. and 9:00 a.m. and simulate a full tank charge. This can be done in a couple of ways:

1. By changing the inventory sensor limit that indicates tank capacity to the energy management system so that it indicates a full tank.
2. By resetting the coolant temperature that indicates a full charge to a higher temperature than the current tank leaving temperature. Verify that the tank charging is stopped.

Step 7: Force the time to be between noon and 6:00 p.m. and simulate no cooling load by setting the indoor temperature setpoint above the ambient temperature. Verify that the tank does not discharge and the compressor is off.

**E 805.15.2 Acceptance Criteria.** Thermal energy storage (TES) system acceptance criteria shall be as follows:

1. Verify that the system is able to charge the storage tank during off-peak periods where there is no cooling load.
2. Verify that tank discharges during on-peak cooling periods.
3. Verify that the compressor does not run and the tank does not discharge where there is no cooling demand during on-peak periods.
4. Verify that the system does not operate during a morning shoulder period where there is no cooling demand.
5. Verify that the system operates in direct mode (with compressor running) during the morning shoulder time period.

**E 806.0 Certificate of Acceptance Forms.**

**E 806.1 General.** This section includes the certificate of acceptance forms referenced in Section E 804.0 and Section E 805.0.
## CERTIFICATE OF ACCEPTANCE

**Outdoor Air Acceptance**

*Project Name/Address:*

*System Name or Identification/Tag:*

*System Location or Area Served:*

**Enforcement Agency:**

*Permit Number:*

*Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.*

### FIELD TECHNICIAN’S DECLARATION STATEMENT

- I certify under penalty of perjury the information provided on this form is true and correct.
- I am the person who performed the acceptance requirements verification reported on this Certificate of Acceptance (Field Technician).
- I certify that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Section E 801.0 through Section E 806.0.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the building permit(s) issued for the building.

**Company Name:**

**Field Technician’s Name:**

**Field Technician’s Signature:**

**Date Signed:**

**Position with Company (Title):**

### RESPONSIBLE PERSON’S DECLARATION STATEMENT

- I certify under penalty of perjury that I am the Field Technician, or the Field Technician is acting on my behalf as my employee or my agent and I have reviewed the information provided on this form.
- I am a licensed contractor or registered design professional who is eligible per the requirements of the Authority Having Jurisdiction to take responsibility for the scope of work specified on this document and attest to the declarations in this statement (responsible person).
- I certify that the information provided on this form substantiates that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Section E 801.0 through Section E 806.0.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the permit(s) issued for the building.
- I will ensure that a completed, signed copy of this Certificate of Acceptance shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a signed copy of this Certificate of Acceptance is required to be included with the documentation the builder provides to the building owner at occupancy.

**Company Name:**

**Responsible Person’s Name:**

**Responsible Person’s Signature:**

**License:**

**Date Signed:**

**Position With Company (Title):**
### Outdoor Air Acceptance

**Project Name/Address:**

**System Name or Identification/Tag:**

**System Location or Area Served:**

**Intent:** Verify measured outside airflow reading is within ±10% of the total required outside airflow value found in Section E 805.1 through Section E 805.2.2

#### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. Watch.
   b. Calibrated means to measure airflow.

2. Check one of the following:
   - **Variable Air Volume (VAV)** - Check as appropriate:
     a. Sensor used to control outdoor air flow must have calibration certificate or be field calibrated.
        - Calibration certificate (attach calibration certification).
        - Field calibration (attach results).
   - **Constant Air Volume (CAV)** - Check as appropriate:
     - System is designed to provide a fixed minimum OSA when the unit is on.

#### Outdoor Air Acceptance

**A. Functional Testing.** (Check appropriate column)  

<table>
<thead>
<tr>
<th>CAV</th>
<th>VAV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Verify unit is not in economizer mode during test - check appropriate column.</td>
</tr>
</tbody>
</table>

**Step 1: CAV and VAV testing at full supply airflow.**

<table>
<thead>
<tr>
<th>CAV</th>
<th>VAV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Adjust supply to achieve design airflow.</td>
</tr>
<tr>
<td>b.</td>
<td>Measured outdoor airflow reading (ft³/min).</td>
</tr>
<tr>
<td>c.</td>
<td>Required outdoor airflow (ft³/min).</td>
</tr>
<tr>
<td>d.</td>
<td>Time for outside air damper to stabilize after VAV boxes open (minutes).</td>
</tr>
<tr>
<td>e.</td>
<td>Return to initial conditions (check).</td>
</tr>
</tbody>
</table>

**Step 2: VAV testing at reduced supply airflow.**

<table>
<thead>
<tr>
<th>CAV</th>
<th>VAV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Adjust supply airflow to either the sum of the minimum zone airflows or 30% of the total design airflow.</td>
</tr>
<tr>
<td>b.</td>
<td>Measured outdoor airflow reading (ft³/min).</td>
</tr>
<tr>
<td>c.</td>
<td>Required outdoor airflow (ft³/min).</td>
</tr>
<tr>
<td>d.</td>
<td>Time for outside air damper to stabilize after VAV boxes open and minimum airflow achieved (minutes).</td>
</tr>
<tr>
<td>e.</td>
<td>Return to initial conditions (check).</td>
</tr>
</tbody>
</table>

**B. Testing Calculations and Results.**

** Percent OSA at full supply airflow (%OA₇₀ for Step 1).**

<table>
<thead>
<tr>
<th>CAV</th>
<th>VAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>%OA₇₀</td>
<td>%OA₇₀</td>
</tr>
<tr>
<td>a.</td>
<td>%OA₇₀ = Measured outside air reading /Required outside air (Step 1b / Step 1c)</td>
</tr>
<tr>
<td>b.</td>
<td>90% ≤ %OA₇₀ ≤ 110%</td>
</tr>
<tr>
<td>c.</td>
<td>Outside air damper position stabilizes within 15 minutes (Step 1d &lt; 15 minutes).</td>
</tr>
</tbody>
</table>

**Percent OSA at reduced supply airflow (%OA₃₀ for Step 2).**

<table>
<thead>
<tr>
<th>CAV</th>
<th>VAV</th>
</tr>
</thead>
<tbody>
<tr>
<td>%OA₃₀</td>
<td>%OA₃₀</td>
</tr>
<tr>
<td>a.</td>
<td>%OA₃₀ = Measured outside air reading/required outside air (Step 2b / Step 2c).</td>
</tr>
<tr>
<td>b.</td>
<td>90% ≤ %OA₃₀ ≤ 110%</td>
</tr>
<tr>
<td>c.</td>
<td>Outside air damper position stabilizes within 15 minutes (Step 2d &lt; 15 minutes).</td>
</tr>
</tbody>
</table>

**Note:** Shaded boxes do not apply for CAV systems.

For SI units: 1 cubic foot per minute = 0.00047 m³/s
CERTIFICATE OF ACCEPTANCE

Outdoor Air Acceptance

Project Name/Address:

System Name or Identification/Tag:     System Location or Area Served:

C. **PASS/FAIL Evaluation** (check one):

- **PASS**: All Construction Inspection responses are complete and Testing Calculations & Results responses are positive (Y – yes).

- **FAIL**: Any Construction Inspection responses are incomplete OR there is one or more negative (N – no) responses in Testing Calculations & Results section. Provide explanation below. Use and attach additional pages if necessary.

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CERTIFICATE OF ACCEPTANCE

Constant Volume Single Zone Unitary Air Conditioner and Heat Pump Systems

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### Intent

Verify the individual components of a constant volume, single-zone, unitary air conditioner and heat pump system function correctly, including: thermostat installation and programming, supply fan, heating, cooling, and damper operation.

### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   - a. None required

2. Installation
   - Thermostat is located within the space-conditioning zone that is served by the HVAC system.

3. Programming (check all of the following):
   - a. Thermostat meets the temperature adjustment and dead band requirements.
   - b. Occupied, unoccupied, and holiday schedules have been programmed per the facility’s schedule.
   - c. Preoccupancy purge has been programmed to meet the requirements of Section E 805.3 through Section E 805.3.2.

### A. Functional Testing Requirements.

#### Operating Modes

<table>
<thead>
<tr>
<th>Operating Modes</th>
<th>Cooling load during unoccupied condition</th>
<th>Cooling load during occupied condition</th>
<th>Manual override</th>
<th>No-load during unoccupied condition</th>
<th>Heating load during unoccupied condition</th>
<th>No-load during occupied condition</th>
<th>Heating load during occupied condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Check and verify the following for each simulation mode required.</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>a.</td>
<td>Supply fan operates continually.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Supply fan turns off.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Supply fan cycles on and off.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>System reverts to “occupied” mode to satisfy any condition.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>System turns off when manual override time period expires.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Gas-fired furnace, heat pump, or electric heater stages on.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g.</td>
<td>Neither heating or cooling is provided by the unit.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h.</td>
<td>No heating is provided by the unit.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>No cooling is provided by the unit.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>j.</td>
<td>Compressor stages on.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>k.</td>
<td>Outside air damper is open to minimum position.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l.</td>
<td>Outside air damper closes completely.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>m.</td>
<td>System returned to initial operating conditions after all tests have been completed:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y/N</td>
</tr>
</tbody>
</table>

### B. Testing Results

<table>
<thead>
<tr>
<th>Indicate if Passed (P), Failed (F), or N/A (X), fill in appropriate letter.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERTIFICATE OF ACCEPTANCE</td>
<td>MECH-3A</td>
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<td>Constant Volume Single Zone Unitary Air Conditioner and Heat Pump Systems</td>
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C. PASS/FAIL Evaluation. (check one):
- [ ] PASS: All **Construction Inspection** responses are complete and **Testing Results** responses are “Pass” (P).
- [ ] FAIL: Any **Construction Inspection** responses are incomplete OR there is one or more “Fail” (F) responses in **Testing Results** section. Provide explanation below. Use and attach additional pages if necessary.
# CERTIFICATE OF ACCEPTANCE

**Air Distribution Systems Acceptance**

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**Intent:**

New single zone supply ductwork must be less than 6% leakage rate per Section E 805.4 through Section E 805.4.2. Existing single zone ductwork must be less than 15% leakage or other compliance path per Section E 805.4 through Section E 805.4.2.

**Construction Inspection**

1. **Scope of test – New Buildings** – this test required on New Buildings only if all check boxes 1(a) through 1(c) are checked.
   - Existing Buildings – this test required if 1(a) through 1(d) are checked.
   - Ductwork conforms to the following (note if any of these are not checked, then this test is not required):
     - 1(a) Connected to a constant volume, single zone air conditioners, heat pumps, or furnaces.
     - 1(b) Serves less than 5000 square feet of floor area.
     - 1(c) Has more than 25% duct surface area located in one or more of the following spaces.
       - Outdoors.
       - A space directly under a roof where the U-factor of the roof is greater than U-factor of the ceiling.
       - A space directly under a roof with fixed vents or openings to the outside or unconditioned spaces.
       - An unconditioned crawlspace.
       - Other unconditioned spaces.
     - 1(d) A duct is extended or any of the following replaced: air handler, outdoor condensing unit of a split system, cooling or heating coil, or the furnace heat exchanger.

2. **Instrumentation to perform test includes:**
   - Duct Pressure Test.

3. **Material and Installation.** Complying new duct systems shall have a checked box for all of the following categories (a) through (g):
   - a. Choice of drawbands. (check one of the following)
     - Stainless steel worm-drive hose clamps.
     - UV-resistant nylon duct ties.
   - b. Flexible ducts are not constricted in any way.
   - c. Duct leakage tests performed before access to ductwork and connections are blocked.
   - d. Joints and seams are not sealed with cloth back rubber adhesive tape unless used in combination with mastic and drawbands.
   - e. Duct R-values are verified R-8 per Section E 805.4 through Section E 805.4.2.
   - f. Ductwork located outdoors has insulation that is protected from damage and suitable for outdoor service.
   - g. A sticker has been affixed to the exterior surface of the air handler access door per Section E 805.4 through Section E 805.4.2.

For SI units: 1 square foot = 0.0929 m²
### Air Distribution Systems Acceptance

**Project Name/Address:**

**System Name or Identification/Tag:**

**System Location or Area Served:**

---

#### Air Distribution System Leakage Diagnostic.

The installing contractor must pressure test every new HVAC systems that meet the requirements of Section E 805.4 through Section E 805.4.2 and every retrofit to existing HVAC systems that meet the requirements of Section E 805.4 through Section E 805.4.2.

### RATED FAN FLOW (applies to all systems)

<table>
<thead>
<tr>
<th>Measured Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cooling capacity or for heating only units heating capacity.</td>
</tr>
<tr>
<td>(a) Cooling capacity (for all units but heating only units) in tons.</td>
</tr>
<tr>
<td>(b) Heating capacity (for heating only units) kBtu/h.</td>
</tr>
<tr>
<td>2. Fan flow calculation</td>
</tr>
<tr>
<td>(a) Cooling capacity in tons [ \text{Line } 1\text{a} \times 400 \text{ ft}^3/\text{min}/\text{ton} ].</td>
</tr>
<tr>
<td>(b) Heating only cap. kBtu/h [ \text{Line } 1\text{b} \times 21.7 \text{ ft}^3/\text{min}/\text{kBtu/h} ].</td>
</tr>
<tr>
<td>3. Total calculated supply fan flow 2(a) or 2(b) ft³/min.</td>
</tr>
</tbody>
</table>

#### NEW CONSTRUCTION OR ENTIRE NEW DUCT SYSTEM ALTERATION:

Duct pressurization test results (ft³/min @ 25 Pa).

| 4. Enter tested leakage flow in ft³/min: | ✔ | ✔ |

#### ALTERATIONS: Pre-existing duct system with duct alteration and/or HVAC equipment change-out.

6. Enter tested leakage flow (cubic feet per minute): Pre-test of existing duct system prior to duct system alteration, equipment change-out, or both.

7. Enter tested leakage flow (cubic feet per minute): Final test of new duct system or altered duct system for duct system alteration, equipment change-out, or both.

#### TEST OR VERIFICATION STANDARDS: For altered duct system and/or HVAC equipment change-out use one of the following three tests or verification standards for compliance:

8. Pass if leakage percentage ≤6%: \[ \frac{\text{Line } 4}{\text{Line } 3} \times 100 \% \] Pass Fail

9. Pass if leakage reduction percentage ≥60%:

   \[
   \text{Leakage reduction} = \left[ 1 - \frac{\text{Line } 7}{\text{Line } 6} \right] \times 100
   \]

   Pass Fail

10. Pass if all accessible leaks are sealed as confirmed by visual inspection and verification by HERS rater (sampling rate 100%). Pass Fail

---

**Pass if One of Lines #8 through #10 pass**

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 cubic foot per minute = 0.00047 m³/s, 1 metric ton = 1000 kg
**CERTIFICATE OF ACCEPTANCE**

**Air Economizer Controls Acceptance**

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## Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. Handheld temperature probes calibration.  
      Date: (must be within last year).  
   b. Multimeter capable of measuring ohms and milliamps.

2. Test method (check one of the following):
   - Economizer comes from HVAC system manufacturer installed by and has been factory calibrated and tested.  
     Attach documentation and complete certification statement. No functional testing required.
   - Economizer field installed and field tested or factory installed and field tested.

3. Installation (check all of the following first level boxes).
   - Economizer lockout setpoint complies with Section E 805.5 through Section E 805.5.2.
   - Economizer lockout control sensor is located to prevent false readings.
   - System is designed to provide up to 100% outside air without over-pressurizing the building.
   - For systems with DDC controls lockout sensor(s) are either factory calibrated or field calibrated.
   - For systems with non-DDC controls, manufacturer’s startup and testing procedures have been applied.

### A. Functional Testing.

#### Step 1: Disable demand control ventilation systems (if applicable).

#### Step 2: Enable the economizer and simulate a cooling demand large enough to drive the economizer fully open (check and verify the following).

- Economizer damper modulates 100% open.
- Return air damper modulates 100% closed.
- Where applicable, verify that the economizer remains 100% open when the cooling demand can no longer be met by the economizer alone.
- All applicable fans and dampers operate as intended to maintain building pressure.
- The unit heating is disabled.

#### Step 3: Simulate a cooling load and disable the economizer (check and verify the following).

- Economizer damper closes to its minimum position.
- All applicable fans and dampers operate as intended to maintain building pressure.
- The unit heating is disabled.

#### Step 4: Simulate a heating demand and enable the economizer (check and verify the following).

- Economizer damper closes to its minimum position.

#### Step 5: System returned to initial operating conditions.

**Y/N**

### B. Testing Results.

| Step 1: Simulate cooling load and enable the economizer (all check boxes are complete). | PASS / FAIL |
| Step 2: Simulate cooling load and disable the economizer (all check boxes are complete). |          |
| Step 3: Simulate heating demand and enable the economizer (all check boxes are complete). |          |
## CERTIFICATE OF ACCEPTANCE

**Air Economizer Controls Acceptance**

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### C. PASS/FAIL Evaluation (check one):

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## CERTIFICATE OF ACCEPTANCE

**MECH-6A**  
Demand Control Ventilation Systems Acceptance

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<th>Position with Company (Title):</th>
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### RESPONSIBLE PERSON’S DECLARATION STATEMENT
- I certify under penalty of perjury that I am the Field Technician, or the Field Technician is acting on my behalf as my employee or my agent and I have reviewed the information provided on this form.
- I am a licensed contractor or registered design professional who is eligible per the requirements of the Authority Having Jurisdiction to take responsibility for the scope of work specified on this document and attest to the declarations in this statement (responsible person).
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</table>
CERTIFICATE OF ACCEPTANCE

Demand Control Ventilation Systems Acceptance

Project Name/Address:

System Name or Identification/Tag: 
System Location or Area Served: 

Intent: Verify that systems required to employ demand controlled ventilation can vary outside ventilation flow rates based on maintaining interior carbon dioxide (CO₂) concentration setpoints.

Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. Calibrated handheld CO₂ analyzer.
   b. Manufacturer’s calibration kit.
   c. Calibrated CO₂/air mixtures.

2. Installation.
   □ The sensor is located in the high density space between 3 feet and 6 feet above the floor or at the anticipated level of the occupants heads.

3. Documentation of all carbon dioxide control sensors includes (check one of the following):
   a. Calibration method.
      □ Factory-calibration certificate (certificate must be attached).
      □ Field calibrated.
   b. Sensor accuracy.
      □ Certified by manufacturer to be no more than +/- 75 ppm calibration certificate must be attached.

A. Functional Testing.

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Disable economizer controls.</td>
</tr>
<tr>
<td>b. Outside air CO₂ concentration (select one of the following).</td>
</tr>
<tr>
<td>□ Measured dynamically using CO₂ sensor.</td>
</tr>
<tr>
<td>c. Interior CO₂ concentration setpoint (Outside CO₂ concentration + 600 ppm).</td>
</tr>
<tr>
<td>ppm</td>
</tr>
</tbody>
</table>

Step 1: Simulate a signal at or slightly above the CO₂ setpoint or follow manufacturers recommended testing procedures.

□ For single zone units, outdoor air damper modulates opens to satisfy the total ventilation air called for in the certificate of compliance.

□ For multiple zone units, either outdoor air damper or zone damper modulates open to satisfy the zone ventilation requirements.

Step 2: Simulate signal well below the CO₂ setpoint or follow manufacturers recommended procedures.

□ For single zone units, outdoor air damper modulates to the design minimum value.

□ For multiple zone units, either outdoor air damper or zone damper modulates to satisfy the reduced zone ventilation requirements.

Step 3: System returned to initial operating conditions. Y/N

B. Testing Results.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Simulate a high CO₂ load (check box complete).</td>
</tr>
<tr>
<td>Step 2: Simulate a low CO₂ load (check box complete).</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm
C. **PASS/FAIL Evaluation**  (check one):

- **PASS:** All **Construction Inspection** responses are complete and **Testing Results** responses are “Pass.”

- **FAIL:** Any **Construction Inspection** responses are incomplete **OR** there is one or more “Fail” responses in **Testing Results** section. Provide explanation below. Use and attach additional pages if necessary.
CERTIFICATE OF ACCEPTANCE

Supply Fan VFD Acceptance

Project Name/Address:

System Name or Identification/Tag: System Location or Area Served:

Enforcement Agency: Permit Number:

Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.

Enforcement Agency Use: Checked by/Date

FIELD TECHNICIAN’S DECLARATION STATEMENT

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Field Technician’s Name: Field Technician’s Signature:

Date Signed: Position with Company (Title):

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Company Name: Phone:

Responsible Person’s Name: Responsible Person’s Signature:

License: Date Signed: Position With Company (Title):
### CERTIFICATE OF ACCEPTANCE

**Supply Fan VFD Acceptance**

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<tr>
<th>Project Name/Address:</th>
<th>System Name or Identification/Tag:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
</table>

** Intent:** Verify that the supply fan in a variable air volume application modulates to meet system airflow demand.

### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   - Calibrated differential pressure gauge.

2. Installation.
   - Discharge static pressure sensors are either factory calibrated or field-calibrated.
   - The static pressure location, setpoint, and reset control meets the requirements of Section E 805.7 through Section E 805.7.2.

3. Documentation of all discharge static pressure sensors including (check one of the following):
   - Field-calibrated.
   - Calibration complete, all pressure sensors within 10% of calibrated reference sensor.

### A. Functional Testing.

#### Step 1: Drive all VAV boxes to achieve design airflow.

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

- a. Supply fan controls modulate to increase capacity.
- b. Supply fan maintains discharge static pressure within +/-10% of the current operating setpoint.
- c. Supply fan controls stabilize within a 5 minute period.

#### Step 2: Drive all VAV boxes to minimum flow.

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

- a. Supply fan controls modulate to decrease capacity.
- b. Current operating setpoint has decreased (for systems with DDC to the zone level).
- c. Supply fan maintains discharge static pressure within +/-10% of the current operating setpoint.
- d. Supply fan controls stabilize within a 5 minute period.

#### Step 3: System returned to initial operating conditions.

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

### B. Testing Results.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASS / FAIL</td>
</tr>
</tbody>
</table>

- Step 1: Drive all VAV boxes to achieve design airflow.
- Step 2: Drive all VAV boxes to minimum flow.

### C. PASS / FAIL Evaluation (check one):

- **PASS:** All Construction Inspection responses are complete and all Testing Results responses are “Pass.”
- **FAIL:** Any Construction Inspection responses are incomplete OR there is one or more “Fail” responses in Testing Results section. Provide explanation below. Use and attach additional pages if necessary.

---

**APPENDIX E**

UNIFORM MECHANICAL CODE - PREPRINT 381
### CERTIFICATE OF ACCEPTANCE

**Valve Leakage Test**

| **Project Name/Address:** | | 
| **System Name or Identification/Tag:** | **System Location or Area Served:** |

| **Enforcement Agency:** | **Permit Number:** |

**Note:** Submit one Certificate of Acceptance for each system that must demonstrate compliance.

#### FIELD TECHNICIAN’S DECLARATION STATEMENT

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| **Company Name:** | | 
| **Field Technician’s Name:** | **Field Technician’s Signature:** |

| **Date Signed:** | **Position with Company (Title):** |

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| **License:** | **Date Signed:** | **Position With Company (Title):** |
### APPENDIX E

#### UNIFORM MECHANICAL CODE - PREPRINT

**CERTIFICATE OF ACCEPTANCE**

**Valve Leakage Test**

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<tr>
<th>Project Name/Address:</th>
<th>System Name or Identification/Tag:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
</table>

**Intent:** Ensure that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation.

#### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   - Calibrated differential pressure gauge.
   - Pump curve submittals showing the shutoff head.
2. Installation.
   - Valve and piping arrangements were installed per the design drawings.

#### A. Functional Testing.

<table>
<thead>
<tr>
<th>Pump Tag (Id)</th>
<th>Results</th>
</tr>
</thead>
</table>

**Step 1: Determine pump dead head pressure.**

a. Close pump discharge isolation valve.  
   - Y / N

b. Measure and record the differential pump pressure.  
   - Feet Water Column =

c. Record the shutoff head from the submittal.  
   - Feet Water Column =

d. The measurement across the pump in step 1b is within 5% of the pump submittal in step 1c.  
   - Y / N

e. Open pump discharge isolation valve.  
   - Y / N

**Step 2: Automatically close all valves on the systems being tested. If three-way valves are present, close off the bypass line(s).**

a. The 2-way valves automatically close.  
   - Y / N

b. Measure and record the differential pump pressure in feet of water column.  
   - Feet Water Column =

c. The measurement across the pump in step 2b is within 5% of the measurement in step 1b.  
   - Y / N

**Step 3: System returned to initial operating conditions.**  
   - Y / N

#### B. Testing Results.

<table>
<thead>
<tr>
<th></th>
<th>PASS / FAIL</th>
</tr>
</thead>
</table>

**Step 1:** Pressure measurement is within 5% of submittal data for all pumps.  
   - ☐ ☐

**Step 2:** Pressure measurements are within 5%.  
   - ☐ ☐

#### C. PASS / FAIL Evaluation (check one):

- ☐ PASS: All Construction Inspection responses are complete and all Testing Results responses are “Pass.”
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---

For SI units: 1 inch water column = 0.249 kPa
# CERTIFICATE OF ACCEPTANCE

**Supply Water Temperature Reset Controls Acceptance**

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<tr>
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**Note:** Submit one Certificate of Acceptance for each system that must demonstrate compliance.

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CERTIFICATE OF ACCEPTANCE

Supply Water Temperature Reset Controls Acceptance

Project Name/Address:  
System Name or Identification/Tag:  
System Location or Area Served:  

Intent: Ensure that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences.

Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. Calibrated reference temperature sensor or drywell bath.
2. Installation
   - Supply water temperature sensors have been either factory or field calibrated.
3. Documentation of hydronic system supply temperature sensors including (check one of the following):
   - Field-calibrated
   - Calibration complete, hydronic system supply temperature sensors within 1% of calibrated reference sensor or drywell bath.

A. Functional Testing.

Step 1: Test maximum reset value.
   a. Change reset control variable to its maximum value. Y / N
   b. Verify that chilled or hot water temperature setpoint is reset to appropriate value. Y / N
   c. Verify that actual system temperature changes to within 2% of the new setpoint. Y / N

Step 2: Test minimum reset value.
   a. Change reset control variable to its minimum value. Y / N
   b. Verify that chilled or hot water temperature setpoint is reset to appropriate value. Y / N
   c. Verify that actual system temperature changes to within 2% of the new setpoint. Y / N

Step 3: Test maximum reset value.
   a. Restore reset control variable to automatic control. Y / N
   b. Verify that chilled or hot water temperature setpoint is reset to appropriate value. Y / N
   c. Verify that actual supply temperature changes to meet setpoint. Y / N
   d. Verify that actual supply temperature changes to within 2% of the new setpoint. Y / N

B. Testing Results.

<table>
<thead>
<tr>
<th>System passes criteria in 1c, 2c, and 3d.</th>
<th>PASS / FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☐</td>
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C. PASS / FAIL Evaluation (check one):

- ☐ PASS: All Construction Inspection responses are complete and all Testing Results responses are “Pass.”
- ☐ FAIL: Any Construction Inspection responses are incomplete OR there is one or more “Fail” responses in Testing Results section. Provide explanation below. Use and attach additional pages if necessary.
CERTIFICATE OF ACCEPTANCE  

Hydronic System Variable Flow Control Acceptance

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Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.

Enforcement Agency Use: Checked by/Date

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<th>Date Signed:</th>
<th>Position With Company (Title):</th>
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</table>


CERTIFICATE OF ACCEPTANCE

Hydronic System Variable Flow Control Acceptance

Project Name/Address:

System Name or Identification/Tag:

System Location or Area Served:

Intent: Ensure that when loads within the building fluctuate, control valves modulate the amount of water passing through each coil and add or remove the desired amount of energy from the air stream to satisfy the load.

Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. Calibrated differential pressure gauge.

2. Installation
   □ Pressure sensors are either factory calibrated or field-calibrated.
   □ Pressure sensor location, setpoint, and reset control meets the requirements of Section E 805.8 through Section E 805.8.2.

3. Documentation of all control pressure sensors including (check one of the following):
   a. Factory-calibrated (proof required).
      □ Factory-calibration certificate.
   b. Field-calibrated.
      □ Calibration complete, all pressure sensors within 10% of calibrated reference sensor.

A. Functional Testing. Results

Step 1: Design flow test.
   a. Open control valves to achieve a minimum of 90% of design flow. Y / N
   b. Verify that the pump speed increases. Y / N
   c. Are the pumps operating at 100% speed? Y / N
   d. Record the system pressure as measured at the control sensor. (Feet Water Column) =
   e. Record the system pressure setpoint. (Feet Water Column) =
   f. Is the pressure reading 1d within 5% of pressure setpoint 1e? Y / N
   g. Did the system operation stabilize within 5 minutes after completion of step 1a? Y / N

Step 2: Low flow test
   a. Close coil control valves to achieve a maximum of 50% of design flow. Y / N
   b. Verify that the current operating speed decreases (for systems with DDC to the zone level). Y / N
   c. Verify that the current operating speed has not increased (for all other systems that are not DDC). Y / N
   d. Record the system pressure as measured at the control sensor. (Feet Water Column) =
   e. Record the system pressure setpoint. (Feet Water Column) =
   f. Is the setpoint in 2e is less than the setpoint in 1d? Y / N
   g. Is the pressure reading 2d within 5% of pressure setpoint 2e? Y / N
   h. Did the system operation stabilize within 5 minutes after completion of step 2a? Y / N

Step 3: System returned to initial operating conditions. Y / N

B. Testing Results

Step 1: Select pass if either 1c or 1f are true.
   □ □

Step 2: Select pass if 2b, 2e, 2f and 2g are true.
   □ □

For SI units: 1 inch water column = 0.249 kPa
CERTIFICATE OF ACCEPTANCE

Hydronic System Variable Flow Control Acceptance

(Certificate of Acceptance)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
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C. PASS / FAIL Evaluation (check one):

- **PASS:** All **Construction Inspection** responses are complete and all **Testing Results** responses are “Pass.”
- **FAIL:** Any **Construction Inspection** responses are incomplete **OR** there is one or more “Fail” responses in **Testing Results** section. Provide explanation below. Use and attach additional pages if necessary.
CERTIFICATE OF ACCEPTANCE

Automatic Demand Shed Control Acceptance

Project Name/Address:  

System Name or Identification/Tag:  

System Location or Area Served:  

Enforcement Agency:  

Permit Number:  

Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.  

Enforcement Agency Use: Checked by/Date  

FIELD TECHNICIAN’S DECLARATION STATEMENT

- I certify under penalty of perjury the information provided on this form is true and correct.
- I am the person who performed the acceptance requirements verification reported on this Certificate of Acceptance (Field Technician).
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Company Name:  

Field Technician’s Name:  

Field Technician’s Signature:  

Date Signed:  

Position with Company (Title):  

RESPONSIBLE PERSON’S DECLARATION STATEMENT

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Responsible Person’s Name:  

Responsible Person’s Signature:  

License:  

Date Signed:  

Position With Company (Title):  

Phone:
**CERTIFICATE OF ACCEPTANCE**

**Automatic Demand Shed Control Acceptance**

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th>System Name or Identification/Tag:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>System Location or Area Served:</td>
</tr>
</tbody>
</table>

**Intent:** Ensure that the central demand shed sequences have been properly programmed into the DDC system.

**Construction Inspection**

1. Instrumentation to perform test includes, but not limited to:
   a. None.
2. Installation.
   - The EMCS front end interface enables activation of the central demand shed controls.

**A. Functional Testing.**

<table>
<thead>
<tr>
<th>Step 1: Engage the demand shed controls.</th>
<th>Pump Tag (Id)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Engage the central demand shed control signal.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b. Verify that the current operating temperature setpoint in a sample of noncritical spaces increases by the proper amount.</td>
<td>Y / N</td>
</tr>
<tr>
<td>c. Verify that the current operating temperature setpoint in a sample of critical spaces does not change.</td>
<td>Y / N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2: Disengage the demand shed controls.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Disengage the central demand shed control signal.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b. Verify that the current operating temperature setpoint in the sample of noncritical spaces returns to their original value.</td>
<td>Y / N</td>
</tr>
<tr>
<td>c. Verify that the current operating temperature setpoint in the sample of critical spaces does not change.</td>
<td>Y / N</td>
</tr>
</tbody>
</table>

**B. Testing Results.**

Test passes if all answers are yes in Step 1 and Step 2.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
</tr>
</thead>
</table>

**C. PASS / FAIL Evaluation (check one):**

- **PASS:** All Construction Inspection responses are complete and all Testing Results responses are “Pass.”
- **FAIL:** Any Construction Inspection responses are incomplete OR there is one or more “Fail” responses in Testing Results section. Provide explanation below. Use and attach additional pages if necessary.
## Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units

### Project Name/Address:

### System Name or Identification/Tag:

### System Location or Area Served:

### Enforcement Agency:

### Permit Number:

**Note:** Submit one Certificate of Acceptance for each system that must demonstrate compliance.

### Enforcement Agency Use: Checked by/Date

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### Date Signed:

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### Phone:

### Responsible Person’s Name:

### Responsible Person’s Signature:

### License:

### Date Signed:

### Position With Company (Title):
CERTIFICATE OF ACCEPTANCE

Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units

Project Name/Address:

System Name or Identification/Tag:

System Location or Area Served:

Intent: The purpose of this test is to verify proper fault detection and reporting for automated fault detection and diagnostics systems for packaged units.

### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. List of instrumentation may be needed or included.

2. Installation.
   - Verify that FDD hardware is installed on equipment by the manufacturer and that equipment make and model include factory-installed FDD hardware that matches the information indicated on copies of the manufacturer’s cut sheets and on the plans and specifications.

### A. Eligibility Criteria Results.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A fault detection and diagnostics (FDD) system for direct-expansion packaged units shall contain the following features to be eligible for credit in the performance calculation method:</td>
<td></td>
</tr>
<tr>
<td>b. The unit shall include a factory-installed economizer and shall limit the economizer dead band to no more than 2°F.</td>
<td>Y/N</td>
</tr>
<tr>
<td>c. The unit shall include direct-drive actuators on outside air and return air dampers.</td>
<td>Y/N</td>
</tr>
<tr>
<td>d. The unit shall include an integrated economizer with either differential dry-bulb or differential enthalpy control.</td>
<td>Y/N</td>
</tr>
<tr>
<td>e. The unit shall include a low temperature lockout on the compressor to prevent coil freeze-up or comfort problems.</td>
<td>Y/N</td>
</tr>
<tr>
<td>f. Outside air and return air dampers shall have maximum leakage rates conforming to Section E 805.12 through Section E 805.12.2.</td>
<td>Y/N</td>
</tr>
<tr>
<td>g. The unit shall have an adjustable expansion control device such as a thermostatic expansion valve (TXV).</td>
<td>Y/N</td>
</tr>
<tr>
<td>h. To improve the ability to troubleshoot charge and compressor operation, a high-pressure refrigerant port will be located on the liquid line. A low-pressure refrigerant port will be located on the suction line.</td>
<td>Y/N</td>
</tr>
<tr>
<td>i. The following sensors should be permanently installed to monitor system operation and the controller should have the capability of displaying the value of each parameter:</td>
<td>Y/N</td>
</tr>
<tr>
<td>- Refrigerant suction pressure</td>
<td></td>
</tr>
<tr>
<td>- Refrigerant suction temp</td>
<td></td>
</tr>
<tr>
<td>- Liquid line pressure</td>
<td></td>
</tr>
<tr>
<td>- Supply air relative humidity</td>
<td></td>
</tr>
<tr>
<td>- Outside air relative humidity</td>
<td></td>
</tr>
<tr>
<td>- Return air temp</td>
<td></td>
</tr>
<tr>
<td>- Supply air relative humidity</td>
<td></td>
</tr>
<tr>
<td>- Return air relative humidity</td>
<td></td>
</tr>
<tr>
<td>- Outside air temp</td>
<td></td>
</tr>
<tr>
<td>j. The controller will provide system status by indicating the following conditions:</td>
<td>Y/N</td>
</tr>
<tr>
<td>- Compressor enabled</td>
<td></td>
</tr>
<tr>
<td>- Economizer enabled</td>
<td></td>
</tr>
<tr>
<td>- Free cooling available</td>
<td></td>
</tr>
<tr>
<td>- Heating enabled</td>
<td></td>
</tr>
<tr>
<td>- Mixed air low limit cycle active</td>
<td></td>
</tr>
<tr>
<td>k. The unit controller shall have the capability to manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified.</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8
B. Functional Testing.

Step 1: Low airflow test.

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Test low airflow condition by replacing the existing filter with a dirty filter or appropriate obstruction.</td>
</tr>
<tr>
<td>b. Verify that the fault detection and diagnostics system reports the fault.</td>
</tr>
<tr>
<td>c. Verify that the system is able to verify the correct refrigerant charge.</td>
</tr>
<tr>
<td>d. Verify that you are able to calibrate the following:</td>
</tr>
<tr>
<td>- Outside Air Temperature Sensor.</td>
</tr>
<tr>
<td>- Return Air Temperature Sensors.</td>
</tr>
<tr>
<td>- Supply Air Temperature Sensors.</td>
</tr>
</tbody>
</table>

C. Testing Results

Test passes if all answers are yes under **Eligibility Criteria** and **Functional Testing**.

- **PASS**: All **Construction Inspection** responses are complete and all **Testing Results** responses are “Pass.”
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**CERTIFICATE OF ACCEPTANCE**

Automatic Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units and Zone Terminal Units Acceptance

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<th>System Name or Identification/Tag:</th>
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<tr>
<th>Date Signed:</th>
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</table>

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**RESPONSIBLE PERSON’S DECLARATION STATEMENT**

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## CERTIFICATE OF ACCEPTANCE

### Automatic Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units and Zone Terminal Units Acceptance

### Project Name/Address: ____________________________

### System Name or Identification/Tag: ____________________________

### System Location or Area Served: ____________________________

### Intent:

*Verify that the system detects common faults in air handling units and zone terminal units.*

---

### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. No instrumentation is required – changes are implemented at the building automation system control station.

2. Installation.
   a. The functional testing verifies proper installation of the controls for FDD for air handling units and zone terminal units. No additional installation checks are required.

---

### A. Eligibility Criteria Results.

#### Testing of each AHU with FDD controls shall include the following tests:

<table>
<thead>
<tr>
<th>Step 1: Sensor Drift/Failure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Disconnect outside air temperature sensor from unit controller</td>
<td>Y/N</td>
</tr>
<tr>
<td>b. Verify that the FDD system reports a fault</td>
<td>Y/N</td>
</tr>
<tr>
<td>c. Connect OAT sensor to the unit controller</td>
<td>Y/N</td>
</tr>
<tr>
<td>d. Verify that FDD indicates normal system operation</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2: Damper/actuator fault</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. From the control system workstation, command the mixing box dampers to full open (100% outdoor air)</td>
<td>Y/N</td>
</tr>
<tr>
<td>b. Disconnect power to the actuator and verify that a fault is reported at the control workstation</td>
<td>Y/N</td>
</tr>
<tr>
<td>c. Reconnect power to the actuator and command the mixing box dampers to full open</td>
<td>Y/N</td>
</tr>
<tr>
<td>d. Verify that the control system does not report a fault</td>
<td>Y/N</td>
</tr>
<tr>
<td>e. From the control system workstation, command the mixing box dampers to a full-closed position (0% outdoor air)</td>
<td>Y/N</td>
</tr>
<tr>
<td>f. Disconnect power to the actuator and verify that a fault is reported at the control workstation</td>
<td>Y/N</td>
</tr>
<tr>
<td>g. Reconnect power to the actuator and command the dampers closed</td>
<td>Y/N</td>
</tr>
<tr>
<td>h. Verify that the control system does not report a fault during normal operation</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3: Valve/actuator fault</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. From the control system workstation, command the heating and cooling coil valves to full open or closed, then disconnect power to the actuator and verify that a fault is reported at the control workstation</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4: Inappropriate simultaneous heating, mechanical cooling, and/or economizing</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. From the control system workstation, override the heating coil valve and verify that a fault is reported at the control workstation</td>
<td>Y/N</td>
</tr>
<tr>
<td>b. From the control system workstation, override the cooling coil valve and verify that a fault is reported at the control workstation</td>
<td>Y/N</td>
</tr>
<tr>
<td>c. From the control system workstation, override the mixing box dampers and verify that a fault is reported at the control workstation</td>
<td>Y/N</td>
</tr>
</tbody>
</table>
## B. Functional Testing for Zone Terminal Units.

Testing shall be performed on one of each type of terminal unit (VAV box) in the project. A minimum of 5% of results the terminal boxes shall be tested.

### Step 1: Sensor Drift/Failure:

| a. | Disconnect the tubing to the differential pressure sensor of the VAV box. | Y / N |
| b. | Verify that control system detects and reports the fault. | Y / N |
| c. | Reconnect the sensor and verify proper sensor operation. | Y / N |
| d. | Verify that the control system does not report a fault. | Y / N |

### Step 2: Damper/actuator fault.

#### If the damper is stuck open:

| a. | Command the damper to be fully open (room temperature above setpoint). | Y / N |
| b. | Disconnect the actuator to the damper. | Y / N |
| c. | Adjust the cooling setpoint so that the room temperature is below the cooling setpoint to command the damper to the minimum position. Verify that the control system reports a fault. | Y / N |
| d. | Reconnect the actuator and restore to normal operation. | Y / N |

#### If the damper is stuck closed:

| a. | Set the damper to the minimum position. | Y / N |
| b. | Disconnect the actuator to the damper. | Y / N |
| c. | Set the cooling setpoint below the room temperature to simulate a call for cooling. Verify that the control system reports a fault. | Y / N |
| d. | Reconnect the actuator and restore to normal operation. | Y / N |

### Step 3: Valve/actuator fault (for systems with hydronic reheat).

| a. | Command the reheat coil valve to full open. | Y / N |
| b. | Disconnect power to the actuator. Set the heating setpoint temperature to be lower than the current space temperature, to command the valve closed. Verify that the fault is reported at the control workstation. | Y / N |
| c. | Reconnect the actuator and restore normal operation. | Y / N |

### Step 4: Feedback loop tuning fault (unstable airflow).

| a. | Set the integral coefficient of the box controller to a value 50 times the current value. Lower the space cooling setpoint to simulate a call for cooling. | Y / N |
| b. | The damper cycles continuously and airflow is unstable. Verify that the control system detects and reports the fault. | Y / N |
| c. | Reset the integral coefficient of the controller to the original value to restore normal operation. | Y / N |

### Step 5: Disconnected inlet duct.

| a. | From the control system workstation, command the damper to full closed, then disconnect power to the actuator and verify that a fault is reported at the control workstation. | Y / N |
### C. Testing Results

Test passes if all answers are yes under **Functional Testing Sections**.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
<th></th>
<th></th>
</tr>
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### D. PASS / FAIL Evaluation (check one):

- **PASS**: All **Construction Inspection** responses are complete and all **Testing Results** responses are “Pass.”
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**CERTIFICATE OF ACCEPTANCE**

Distributed Energy Storage DX AC Systems Acceptance

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</tr>
<tr>
<td>Date Signed:</td>
<td>Position With Company (Title):</td>
</tr>
</tbody>
</table>
### Intent:
Verify that the system detects common faults in air handling units and zone terminal units.

### Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. No special instrumentation is required to perform these tests.

2. Installation.
   Prior to Performance Testing, verify and document the following:
   - The water tank is filled to the proper level.
   - The water tank is sitting on a foundation with adequate structural strength.
   - The water tank is insulated and the top cover is in place.
   - The DES/DXAC is installed correctly (refrigerant piping, etc.).
   - Verify that the correct model number is installed and configured.

### A. Functional Testing

#### Step 1: Simulate no cooling load during a nighttime period by setting system time to between 9:00 p.m. and 6:00 a.m. Raise the space temperature setpoint above the current space temperature. Verify and document the following:

- a. The system charges the tank. **Y** / **N**
- b. The system does not provide cooling to the building. **Y** / **N**

#### Step 2: Simulate cooling load during daytime period (e.g., by setting time schedule to include actual time and placing thermostat cooling set-point below actual temperature). Verify and document the following:

- a. Supply fan operates continually during occupied hours. **Y** / **N**
- b. If the DES/DXAC has cooling capacity, DES/DXAC runs to meet the cooling demand (in ice melt mode). **Y** / **N** / **N/A**
- c. If the DES/DXAC has no ice and there is a call for cooling, the DES/DXAC runs in direct cooling mode. **Y** / **N** / **N/A**

#### Step 3: Simulate no cooling load during daytime condition. Verify and document the following:

- a. Supply fan operates as per the facility thermostat or control system. **Y** / **N**
- b. The DES/DXAC and the condensing unit do not run.

#### Step 4: Simulate no cooling load during morning shoulder time period. Verify and document the following:

- a. The DES/DXAC is idle (the condensing unit and the refrigerant pumps remain off). **Y** / **N**

### B. Calibrating Controls

#### Results

- a. Verify that you are able to set the proper time and date, as per manufacturer’s installation manual for approved installers. **Y** / **N**

### C. Testing Results

Test passes if all answers are yes under Functional Testing and Calibrating Controls. **☐** / **☐**

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW
### DISTRIBUTED ENERGY STORAGE DX AC SYSTEMS ACCEPTANCE

#### CERTIFICATE OF ACCEPTANCE

**MECH-14A**

**Distributed Energy Storage DX AC Systems Acceptance**  
(Page 3 of 3)

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Name or Identification/Tag:</td>
<td></td>
</tr>
<tr>
<td>System Location or Area Served:</td>
<td></td>
</tr>
</tbody>
</table>

- **PASS:** All Construction Inspection responses are complete and all Testing Results responses are “Pass.”
- **FAIL:** Any Construction Inspection responses are incomplete **OR** there is one or more “Fail” responses in Testing Results section. Provide explanation below. Use and attach additional pages if necessary.

<table>
<thead>
<tr>
<th>Explanation of Failure:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage:</td>
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</tr>
<tr>
<td>Result:</td>
<td></td>
</tr>
<tr>
<td>Test:</td>
<td></td>
</tr>
<tr>
<td>Equipment:</td>
<td></td>
</tr>
<tr>
<td>Test Equipment:</td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td></td>
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<tr>
<td>Test Location:</td>
<td></td>
</tr>
<tr>
<td>Test Description:</td>
<td></td>
</tr>
<tr>
<td>Test Methodology:</td>
<td></td>
</tr>
<tr>
<td>Test Conditions:</td>
<td></td>
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<tr>
<td>Test Data:</td>
<td></td>
</tr>
<tr>
<td>Test Results:</td>
<td></td>
</tr>
<tr>
<td>Test Conclusion:</td>
<td></td>
</tr>
<tr>
<td>Test Action:</td>
<td></td>
</tr>
</tbody>
</table>

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**UNIFORM MECHANICAL CODE - PREPRINT**

400
# Certificate of Acceptance

**Thermal Energy Storage (TES) System Acceptance**

**MECH-15A**

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enforcement Agency:</th>
<th>Permit Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Submit one Certificate of Acceptance for each system that must demonstrate compliance.

---

## Field Technician’s Declaration Statement

- I certify under penalty of perjury the information provided on this form is true and correct.
- I am the person who performed the acceptance requirements verification reported on this Certificate of Acceptance (Field Technician).
- I certify that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Section E 801.0 through Section E 806.0.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the building permit(s) issued for the building.

<table>
<thead>
<tr>
<th>Company Name:</th>
<th>Field Technician’s Name:</th>
<th>Field Technician’s Signature:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Date Signed:</th>
<th>Position with Company (Title):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Responsible Person’s Declaration Statement

- I certify under penalty of perjury that I am the Field Technician, or the Field Technician is acting on my behalf as my employee or my agent and I have reviewed the information provided on this form.
- I am a licensed contractor or registered design professional who is eligible per the requirements of the Authority Having Jurisdiction to take responsibility for the scope of work specified on this document and attest to the declarations in this statement (responsible person).
- I certify that the information provided on this form substantiates that the construction/installation identified on this form complies with the acceptance requirements indicated in the plans and specifications approved by the enforcement agency, and conforms to the applicable acceptance requirements and procedures specified in Section E 801.0 through Section E 806.0.
- I have confirmed that the Installation Certificate(s) for the construction/installation identified on this form has been completed and is posted or made available with the permit(s) issued for the building.
- I will ensure that a completed, signed copy of this Certificate of Acceptance shall be posted, or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a signed copy of this Certificate of Acceptance is required to be included with the documentation the builder provides to the building owner at occupancy.

<table>
<thead>
<tr>
<th>Company Name:</th>
<th>Phone:</th>
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</thead>
<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>Responsible Person’s Name:</th>
<th>Responsible Person’s Signature:</th>
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<table>
<thead>
<tr>
<th>License:</th>
<th>Date Signed:</th>
<th>Position With Company (Title):</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>
APPENDIX E

CERTIFICATE OF ACCEPTANCE
MECH-15A
Thermal Energy Storage (TES) System Acceptance (Page 2 of 3)

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th>System Name or Identification/Tag:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
</table>

Intent: Verify proper operation of distributed energy storage DX systems.

Construction Inspection

1. Instrumentation to perform test includes, but not limited to:
   a. No special instrumentation is required for the acceptance tests.

A. Certificate of Compliance Information

The following Certificate of Compliance information for both the chiller and the storage tank shall be provided on the plans to document the key TES System parameters and allow plan check comparison to the inputs used in the DOE-2 simulation. DOE-2 keywords are shown in ALL CAPITALS in parentheses.

<table>
<thead>
<tr>
<th>a. Chiller</th>
<th>Brand and Model:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type (centrifugal, reciprocating, etc):</td>
</tr>
<tr>
<td></td>
<td>Capacity (tons): (Size)</td>
</tr>
<tr>
<td></td>
<td>Starting Efficiency (kW/ton): (at beginning of ice production) (COMP-kW/TON-START)</td>
</tr>
<tr>
<td></td>
<td>Ending Efficiency (kW/ton): (at end of ice production) (COMP-kW/TON-END)</td>
</tr>
<tr>
<td></td>
<td>Capacity Reduction (% / F): (PER-COMP-REDUCT/F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. Storage Tank</th>
<th>Storage Type (Check): (TES-TYPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□ Chilled Water Storage</td>
</tr>
<tr>
<td></td>
<td>□ Ice-on-Coil Storage</td>
</tr>
<tr>
<td></td>
<td>□ CHS Ice Harvester</td>
</tr>
<tr>
<td></td>
<td>□ Brine Ice Harvester</td>
</tr>
<tr>
<td></td>
<td>□ Ice-Slurry Storage</td>
</tr>
<tr>
<td></td>
<td>□ Eutectic Salt Storage</td>
</tr>
</tbody>
</table>

|            | Number of tanks (SIZE) |
|            | Storage Capacity per Tank (ton-hours) |
|            | Storage Rate (tons): (COOL-STORE-RATE) |
|            | Discharge Rate (tons): (COOL-SUPPLY-RATE) |
|            | Auxiliary Power (watts): (PUMP+AUX-kW) |
|            | Tank Area (square feet): (CTANK-LOSS-COEFF) |
|            | Tank Insulation (R-Value): (CTANK-LOSS-COEFF) |

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW
### B. Functional Testing

#### Step 1: TES System Design Verification

- **a.** In the TES System Design Verification part, the installing contractor shall certify the following information, which verifies proper installation of the TES System consistent with system design expectations:
  - The TES system is one of the above eligible systems
  - Initial charge rate of the storage tanks (tons)
  - Final charge rate of the storage tank (tons)
  - Tank standby storage losses (UA)
  - Initial discharge rate of the storage tanks (tons)
  - Final discharge rate of the storage tank (tons)
  - Charge test time (hours)
  - Initial chiller efficiency (kW/ton) during charging
  - Discharge test time (hours)
  - Tank storage capacity after charge (ton-hours)
  - Tank storage capacity after discharge (ton-hours)
  - Final chiller efficiency (kW/ton) during charging

#### Step 2: TES System Controls and Operation Verification

- **a.** The TES system and the chilled water plant is controlled and monitored by an EMS.
- **b.** Force the time between 9:00 p.m. and 9:00 a.m. and simulate a partial or no charge of the tank and simulate no cooling load by setting the indoor temperature setpoint higher than the ambient temperature. Verify that the TES system starts charging (storing energy).
- **c.** Force the time to be between 6:00 p.m. and 9:00 p.m. and simulate a partial charge on the tank and simulate a cooling load by setting the indoor temperature set point lower than the ambient temperature. Verify that the TES system starts discharging.
- **d.** Force the time to be between noon and 6:00 p.m. and simulate a cooling load by lowering the indoor air temperature set point below the ambient temperature. Verify that the tank starts discharging and the compressor is off. For systems designed to meet partial loads the system should be run until the TES storage is fully depleted. The number of hours of operation must meet or exceed the designed operational hours for the system.
- **e.** Force the time to be between 9:00 a.m. to noon, and simulate a cooling load by lowering the indoor air temperature set point below the ambient temperature. Verify that the tank does not discharge and the cooling load is met by the compressor only.
- **f.** Force the time to be between 9:00 p.m. and 9:00 a.m. and simulate a full tank charge by changing the output of the sensor to the EMS. Verify that the tank charging is stopped.
- **g.** Force the time to be between noon and 6:00 p.m. and simulate no cooling load by setting the indoor temperature set point above the ambient temperature. Verify that the tank does not discharge and the compressor is off.

#### C. PASS / FAIL Evaluation (check one):

- **PASS:** All Construction Inspection responses are complete and all Testing Results responses are “Pass.”
- **FAIL:** Any Construction Inspection responses are incomplete OR there is one or more “Fail” responses in Testing Results section. Provide explanation below. Use and attach additional pages if necessary.

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW
APPENDIX F
GEOTHERMAL ENERGY SYSTEMS

Part I Closed-Loop Systems.

F 101.0 General.
F 101.1 Applicability. Part I of this appendix shall apply to geothermal energy systems such as, but not limited to, building systems coupled with a ground-heat exchanger, submerged heat exchanger or groundwater (well) using water-based fluid as a heat transfer medium. The regulations of this appendix 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 F 104.7 and Chapter 12.

F 101.1.2 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.

F 102.0 Definitions.
Geothermal Energy System. A system that uses thermal energy for space heating and cooling, and water heating.
Geothermal Energy System, Closed-Loop. A continuous, sealed, underground, or submerged heat exchanger through which a heat-transfer fluid passes to and returns from a heat pump.
Geothermal Energy System, Open-Loop. A liquid-source heat pump system that uses ground water or surface water to extract or reject heat.
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.
Groundwater Source. A geothermal energy system that uses the groundwater as a heat source or sink.
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.
F 102.1 Construction Documents. The construction documents for the building system portion of the geothermal energy system shall be submitted to the Authority Having Jurisdiction.

F 102.2 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:
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.
F 102.3 Decommissioning and Abandonment. Prior to the abandonment or decommissioning of a ground-heat exchanger, submerged heat exchanger or ground water (well) the owner shall obtain the necessary permits from the Authority Having Jurisdiction.
E 505.4F 102.4 Used Materials. The installation of used pipe, fittings, valves, and other materials shall not be permitted.
E 508.5 F 102.5 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.
E 508.6 F 102.6 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.
E 508.7 F 102.7 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.
E 508.8 F 102.8 Pipe Support. Pipe shall be supported in accordance with Section 313.1.
E 508.9 F 102.9 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.
E 508.11 F 102.10 Chemical Compatibility. Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings, and mechanical systems.
E 508.12 F 102.11 Transfer Fluid. The transfer fluid shall be compatible with the makeup water supplied to the system.

F 103.0 Groundwater Systems.
F 103.1 General. The potable water supply connected to a groundwater system shall be protected with an approved
system shall be installed as follows:

F 104.2 Installation Practices. A ground-heat exchanger system shall be provided to the owner to confirm that the loop flow is in accordance with the construction documents.

F 104.4 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. CSA 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.

F 104.4.1 Backfill. Bentonite grout and thermally-enhanced bentonite grout, where used to seal and back-
fill each borehole, shall comply with NSF 60. Boreholes shall be backfilled in accordance with the Authority Having Jurisdiction.

**F 104.4.2 U-Bends and Header.** Headers, u-bends and ground loop pipes shall be pressure-tested in accordance with CSA 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.

**F 104.4.2.1 Test Pressure.** The maximum test pressure shall be 1.5 times the system design pressure, as determined by Section F 104.4.2.3, or Section F 104.4.2.4, not to exceed 100 psi (689 kPa). Components or devices with lower pressure-ratings than the pipe shall be protected from excessive pressure during testing by removing or isolating from the test section.

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

**F 104.4.2.2 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 make-up 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 make-up 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.

**F 104.4.2.3 Calculation of Static Pressure (Water).** For water, the static pressure applied shall be equivalent to 0.43 psi (2.96 kPa) per foot (305 mm) of elevation.

**F 104.4.2.4 Calculation of Static Pressure (Other Fluids).** For fluids of different density, the static pressure shall be calculated using the density of the system fluid.

**E 505.5_F 104.5 Piping and Tubing Materials Standards.** For water-based systems, ground source heat pump ground-loop pipe and tubing shall comply with the standards listed in Table E-505.5_F 104.5. Piping and tubing used for DX systems shall be of copper in accordance with Section F 104.8.

**E 505.6 F 104.6 Fittings.** For water-based systems, fittings for ground source heat pump systems shall be of copper in accordance with Section F 104.8.

**Table E-505.5_F 104.5 Plastic Ground Source Loop Piping**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F1437; ASTM F1438; ASTM F1490; ASTM F1070; CSA B137.6</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F877; ASTM F1055; ASTM F1807; ASTM F1960; ASTM F2080; ASTM F2159; ASTM F2434; CSA B137.5; CSA C448; NSF 358-3</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe</td>
<td>ASTM F1282; CSA B137.9</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene chlorinated (PVC)</td>
<td>ASTM D2737; ASTM D3035; ASTM F714; AWAC C901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polyethylene raised temperature (PE-RT)</td>
<td>ASTM F2623; ASTM F2769; CSA B137.18; CSA C448</td>
</tr>
</tbody>
</table>

**Table E-505.6_F 104.6 Ground Source Loop Pipe Fittings**

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F1437; ASTM F1438; ASTM F1490; ASTM F1070; CSA B137.6</td>
</tr>
<tr>
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</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene chlorinated (PVC)</td>
<td>ASTM D2737; ASTM D3035; ASTM F714; AWAC C901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polyethylene raised temperature (PE-RT)</td>
<td>ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe</td>
<td>ASTM F1282; ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene chlorinated (PVC)</td>
<td>ASTM D2737; ASTM D3035; ASTM F714; AWAC C901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polyethylene raised temperature (PE-RT)</td>
<td>ASTM D2683; ASTM D3261; ASTM F1055; ASTM F1807; ASTM F2080; ASTM F2159; ASTM F2769; CSA B137.18; CSA C448</td>
</tr>
</tbody>
</table>

**F 104.7 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 F 104.7.1 and Section F 104.7.1.1, or
APPENDIX F

cross-linked polyethylene (PEX) pipe or tubing in accordance with Section F 104.7.2 and Section F 104.7.2.1.

F 104.7.1 Polyethylene (PE). Polyethylene pipe or tubing shall be manufactured in accordance with the standards listed in Table F 104.5. Pipe or tubing shall have a maximum dimension ratio of 11 and shall have a minimum pressure rating of not less than 160 psi (1103 kPa) at 73°F (23°C).

Polyethylene pipe and 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 F 104.5, 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.

F 104.7.1.1 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 F 104.6, 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.

F 104.7.2 Cross-Linked Polyethylene (PEX). Cross-linked polyethylene pipe shall be manufactured in accordance with the standards listed in Table F 104.6. 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).

F 104.7.2.1 Joining Methods for Cross-Linked Polyethylene Tubing. Joints between cross-linked polyethylene (PEX) tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions and the appropriate standards in accordance with Table F 104.6.

F 104.8 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.

F 104.9 Indoor Piping. Indoor piping, fittings, and accessories that are part of the groundwater system shall be in accordance with Chapter 12. Such materials shall be rated for the operating temperature and pressures of the system and shall be compatible with the type of transfer medium. For DX systems, joints shall be purged with an inert gas and brazed with a brazing alloy having 15 percent silver content in accordance with AWS A5.8.

F 105.0 Installation.

F 105.1 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.

F 105.2 Trenches, Tunneling, and Driving. Trenches shall comply with Section 317.1. Tunneling and driving shall comply with Section 317.2.

F 105.3 Excavations and Open Trenches. Excavations required to be made for the installation of piping or tubing shall be in accordance with Section 317.3. 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 317.4.

F 105.4 Protection of Piping, Materials, and Structures. Piping and tubing passing under or through walls shall be protected from breakage in accordance with Section 316.1. Piping and tubing shall be installed in accordance with Section 316.2 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.

F 105.5 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 316.7 through Section 316.7.2.

F 105.6 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 316.6.

E 509.2 F 105.7 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.

F 106.0 Specific System Components Design.

F 106.1 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 1218.1. 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.
A pump distribution system shall be designed as follows:

- A means to indicate that the compressor is locked out.

All heat pump equipment used in DX systems shall comply with AHRI 870. Heat pumps shall be fitted with ASHRAE 194. All heat pump equipment used in DX systems shall be certified in accordance with AHRI/ASHRAE/ISO 13256-2 for water-to-water heat pumps. DX heat pumps shall be certified in accordance with AHRI/ASHRAE/ISO 13256-1 for water-to-air heat pumps.

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**F 106.2 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 (27.8°C) above the maximum system operating temperature. For DX systems, the heat transfer medium shall be a refrigerant listed in ASHRAE 34 or this code.

**F 106.3 On Site Storage.** Exterior piping shall be fitted with end caps and protected from freezing, UV radiation, corrosion, and degradation. For DX systems, copper piping and fittings shall be stored to prevent physical damage, contamination, and each pipe or tubing shall be pressurized with an inert gas and sealed with a cap.

**F 106.4 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.

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**F 107.0 Ground-Heat Exchanger Testing.**

**F 107.1 Testing.** Pressure-testing of the ground-heat exchanger shall be performed in accordance with the testing method in Section F 104.4.

**F 107.2 DX System Testing.** For DX systems, each loop shall be tested with an inert gas at not less than 315 psi (2172 kPa) for not less than 15 minutes without pressure drop. The pressure reading after grouting of the boreholes shall be maintained in the ground-heat exchanger for not less than 2 hours.

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**F 108.0 Heat Pump and Distribution System Design.**

**F 108.1 General.** Ground coupled and water source heat pumps shall be certified in accordance with AHRI/ASHRAE/ISO 13256-1 for water-to-air heat pumps and AHRI/ASHRAE/ISO 13256-2 for water-to-water heat pumps. DX heat pumps shall be certified in accordance with ASHRAE 194. All heat pump equipment used in DX systems shall comply with AHRI 870. Heat pumps shall be fitted with a means to indicate that the compressor is locked out.

**F 108.2 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 313.0 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.

**F 108.3 Circulating Pumps.** The circulating pump shall be sized for the operating conditions and the heat transfer fluid properties.

**F 108.4 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.

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**F 109.0 System Start-Up.**

**F 109.1 General.** The following requirements shall be verified prior to system start-up:

1. Piping shall be cleaned, flushed, and purged.
2. DX systems shall be pressurized using nitrogen for not less than 1 hour. There shall be no allowable variance to the test pressure after being corrected for ambient temperature changes during the test. The test pressure shall not exceed 150 psig (1034 kPa) when pressure testing the compressor unit and indoor system components.
3. The ground heat exchanger and building piping shall be cleaned, flushed, and, where required, shall be filled with the heat transfer fluid medium. The ground loop system shall be tested at the design flow rate(s) and differential pressure(s) recorded. Where the actual pressure change at design flow is more than +/- 10 percent of the design flow pressure drop, the cause shall be identified and corrective action taken.
4. A method for the removal of air and a method for adding heat transfer fluid (where necessary) shall be provided.
5. The heat pumps shall be operational and adjustments shall be made in accordance with the manufacturer’s installation instructions.
6. All necessary additional flow tests of the ground heat exchanger shall be completed prior to heat pump start-up.
7. Ground heat exchanger and building piping, valves, and operating controls, shall be set, adjusted, and operating as required.
8. 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.
(9) DX systems shall have permanent type labels installed and affixed on the compressor unit with the refrigerant type and quantity.

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

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

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

F 109.2 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.

E 508.40 F 109.3 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.

E 507.0 F 110.0 Valves.

E 507.1 F 110.1 Where Required. Shutoff valves shall be installed in ground-source-loop piping systems in the locations indicated in Section E 507.2 F 110.2 through Section E 507.8 F 110.8.

E 507.2 F 110.2 Heat Exchangers. Shutoff valves shall be installed on the supply and return side of a heat exchanger, except 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.

E 507.3 F 110.3 Central Systems. Shutoff valves shall be installed on the building supply and return of a central utility system.

E 507.4 F 110.4 Pressure Vessels. Shutoff valves shall be installed on the connection to a pressure vessel.

E 507.5 F 110.5 Pressure-Reducing Valves. Shutoff valves shall be installed on both sides of a pressure-reducing valve.

E 507.6 F 110.6 Equipment and Appliances. Shutoff valves shall be installed on connections to mechanical equipment and appliances. This requirement does not apply to components of a ground source loop system such as pumps, air separators, metering devices, and similar equipment.

E 507.7 F 110.7 Expansion Tanks. Shutoff valves shall be installed at connections to nondiaphragm-type expansion tanks.

E 507.8 F 110.8 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.

Part II – Open-Loop Systems.

F 201.0 General.

F 201.1 Applicability. Part II of this appendix 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 appendix 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 F 104.7 and Chapter 12.

F 201.1.2 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.

F 201.2 Construction Documents. The construction documents for the building system portion of the geothermal energy system shall be submitted to the Authority Having Jurisdiction.

F 201.3 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.

F 201.4 Subsurface investigation. A subsurface investigation shall be performed in accordance with Section F 201.4.1 as determined by the registered design professional conducting the site survey.

F 201.4.1 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, salt-water intrusions, contaminated soils and groundwater,
hazardous gases, and any interference with neighboring water wells and ground source heat exchangers.

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

**F 201.5 Setbacks.** Open loop ground-heat exchangers shall maintain the following minimum setbacks or at distances specified by the Authority Having Jurisdiction:

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

**F 202.0 Open Ground Water Systems.**

**F 202.1 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.

**F 202.2 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.

**F 202.3 Design Considerations.** A groundwater heat pump system shall be designed by a registered design professional. Due design consideration shall be given to the following:

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

**F 202.4 Water Wells and Injection Wells.** Water wells and injection wells for groundwater heat pump systems shall be installed and tested by a registered design professional who 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.

**F 202.5 Testing and Sampling.** Pumping tests and water sampling shall be done as required by the registered design professional.

**F 202.6 Disinfection.** Water wells shall be disinfected upon completion in accordance with requirements of the Authority Having Jurisdiction and NGWA-01.

**F 203.0 Horizontal Piping from Extraction Wells and to Injection Wells - Materials and Methods.**

**F 203.1 Piping material.** Piping materials and joining methods for horizontal piping from extraction wells and to injection wells shall in accordance with Section F 104.5, Section F 104.6, Section F 104.7, Section F 104.8 and Section F 104.9.

**F 203.1.1 Dissimilar Materials.** Transition fittings between dissimilar materials shall be inside or accessible.

**F 203.1.2 Protection of Piping.** Pipes passing through walls shall be sleeved and sealed in accordance with Section 316.0.

**F 203.2 Trenches, Excavation, and Backfilled.** Excavation for horizontal piping shall comply with Section F 203.2.1 through Section F 203.2.8, Section F 105.1 through Section F 105.4, 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.

**F 203.2.1 Trenches.** Trenches for underground piping or tubing shall be excavated in accordance with the setbacks requirements in Section F 201.5.
F 203.2.2 Buried Systems. Buried open-loop system piping shall be installed not less than 3.3 feet (1006 mm) below the finished grade.

F 203.2.3 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.

F 203.2.4 Separation. The horizontal piping shall be separated from fluid-based on-site services systems to prevent excessive short-circuiting heat transfer between such systems.

F 203.2.5 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.

F 203.2.6 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.

F 203.2.7 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 R2 minimum closed cell insulation.

F 203.2.8 Tracer Markings. Means shall be provided for underground detection or utility location of the buried pipe system. This shall include, but is not limited to metallic detectable tape, with a thickness of not less than 11/64 of an inch (4.4 mm) and width of 6 inches (152 mm).

This warning marking shall be permanent, conspicuous and resistant to the environmental conditions and shall be placed within 1 foot to 2 feet (305 mm to 610 mm) on top of the horizontal piping of the heat exchanger installation.

F 204.0 Testing and Verification.
F 204.1 Pumping Test. Water supply wells and injection wells shall undergo a stop and start pumping test to demonstrate the sand-free yield.

F 204.2 Retesting. Where sediment is present, the problem shall be corrected and the test shall be repeated until acceptable results are obtained.

F 204.3 Variable Rate Pump Test. The operating conditions of the water supply wells and injection wells shall be evaluated and verify with a variable rate pumping.

F 204.4 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 duration as specified by the registered designed professional.

F 204.5 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 designed professional.

F 204.6 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 designed professional. The results of the drilling and pumping tests shall be provided to the owner or the owner’s representative and provided in accordance with requirements of the Authority Having Jurisdiction.

F 204.7 Re-Injected Water. The water quality of re-injected water into the earth shall comply with the requirements of the Authority Having Jurisdiction.

F 205.0 System Start-Up and Delivery.
F 205.1 Documentation. The ground source heat pump system as-built installation drawings and instructions shall be provided to the building owner or designated agent.

F 205.2 Maintenance. The periodic maintenance required, in accordance with the design requirements, shall be provided and be made available to the owner or designated agent.

F 205.3 Records. The ground source heat pump system construction documents shall be provided to the owner.

F 205.4 System Start-Up. System startup shall be in accordance with CSA C448.1, CSA C448.2, and Section F 206.0.

F 205.5 Contaminants. Particulate contaminants shall be removed from indoor piping system prior to initial start-up.

F 206.0 Decommissioning and Abandonment.
F 206.1 General. Prior to the abandonment or decommissioning of an open-loop system, the owner shall obtain the necessary permits from the Authority Having Jurisdiction.
APPENDIX FG
SIZING OF VENTING SYSTEMS AND OUTDOOR COMBUSTION
AND VENTILATION OPENING DESIGN

(The content of this Appendix is based on Annex F and Annex I of NFPA 54)

FG 101.0 General.

FG 101.1 Applicability. This appendix provides general guidelines for sizing venting systems serving appliances equipped with draft hoods, Category I appliances, and appliances listed for use with Type B vents.

FG 101.2 Examples Using Single Appliance Venting Tables. See Figure FG 101.2(1) through Figure FG 101.2(14).

Table 803.1.2(1) is used where sizing a Type B double-wall gas vent connected directly to the appliance.

Note: The appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.

Table 803.1.2(2) is used where sizing a single-wall metal vent connector attached to a Type B double-wall gas vent.

Note: The appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.

Table 803.1.2(3) is used where sizing a Type B double-wall gas vent connector attached to a tile-lined masonry chimney.

Notes:
1. A is the equivalent cross-sectional area of the tile liner.
2. The appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.

Table 803.1.2(4) is used where sizing a single-wall vent connector attached to a tile-lined masonry chimney.

Notes:
1. A is the equivalent cross-sectional area of the tile liner.
2. The appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.
Asbestos cement Type B or single-wall metal vent serving a single draft hood-equipped appliance. [See Table 803.1.2(5)]

**FIGURE EG 101.2(5)**

ASBESTOS CEMENT TYPE B OR SINGLE-WALL METAL VENT SYSTEM SERVING A SINGLE DRAFT HOOD-EQUIPPED APPLIANCE

Table 803.2(1) is used where sizing Type B double-wall gas vent connectors attached to a Type B double-wall common vent.

**FIGURE EG 101.2(6)**

VENT SYSTEM SERVING TWO OR MORE APPLIANCES WITH TYPE B DOUBLE-WALL VENT AND TYPE B DOUBLE-WALL VENT CONNECTORS

Table 803.2(2) is used where sizing single-wall vent connectors attached to a Type B double-wall common vent.

**FIGURE EG 101.2(7)**

VENT SYSTEM SERVING TWO OR MORE APPLIANCES WITH TYPE B DOUBLE-WALL VENT AND SINGLE-WALL METAL VENT CONNECTORS

Table 803.2(3) is used where sizing Type B double-wall vent connectors attached to a tile-lined masonry chimney.

**FIGURE EG 101.2(8)**

MASONRY CHIMNEY SERVING TWO OR MORE APPLIANCES WITH TYPE B DOUBLE-WALL VENT CONNECTORS

Note: Each appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.

Notes:
1. $A$ is the equivalent cross-sectional area of the tile liner.
2. The appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.
Table 803.2(4) is used where sizing single-wall metal vent connectors attached to a tile-lined masonry chimney.

**Notes:**
1. \(A\) is the equivalent cross-sectional area of the tile liner.
2. Each appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.

**Example:** Manifolded common vent connector \(L_M\) can be no greater than 18 times the common vent connector manifold inside diameter; that is, a 4 inch (102 mm) inside diameter common vent connector manifold shall not exceed 72 inches (1829 mm) in length. [See Section 803.2.3]

**Note:** This is an illustration of a typical manifolded vent connector. Different appliance, vent connector, or common vent types are possible. [See Section 803.2]

Asbestos cement Type B or single-wall metal pipe vent serving two or more draft hood-equipped appliances. [See Table 803.2(5)]

**Example:** Offset common vent

**Note:** This is an illustration of a typical offset vent. Different appliance, vent connector, or vent types are possible. [See Section 803.1 and Section 803.2]
Example 1: Single Draft Hood-Equipped Appliance. An installer has a 120,000 British thermal units per hour (Btu/h) (35 kW) input appliance with a 5 inch (127 mm) diameter draft hood outlet that needs to be vented into a 10 foot (3048 mm) high Type B vent system. What size vent should be used assuming: (1) a 5 foot (1524 mm) lateral single-wall metal vent connector is used with two 90 degree (1.57 rad) elbows or (2) a 5 foot (1524 mm) lateral single-wall metal vent connector is used with three 90 degree (1.57 rad) elbows in the vent system? (See Figure FG 101.3)

Solution:
Table 803.1.2(2) shall be used to solve this problem because single-wall metal vent connectors are being used with a Type B vent, as follows:

1. Read down the first column in Table 803.1.2(2) until the row associated with a 10 foot (3048 mm) height and 5 foot (1524 mm) lateral is found. Read across this row until a vent capacity exceeding 120,000 Btu/h (35 kW) is located in the shaded columns labeled NAT Max for draft hood-equipped appliances. In this case, a 5 inch (127 mm) diameter vent has a capacity of 122,000 Btu/h (35.7 kW) and shall be permitted to be used for this application.

2. Where three 90 degree (1.57 rad) elbows are used in the vent system, the maximum vent capacity listed in the tables shall be reduced by 10 percent. This implies that the 5 inch (127 mm) diameter vent has an adjusted capacity of only 110,000 Btu/h (32 kW). In this case, the vent system shall be increased to 6 inches (152 mm) in diameter. See the following calculations:

\[
122,000 \text{ Btu/h (35.7 kW) } \times 0.90 = 110,000 \text{ Btu/h (32 kW)} \text{ for 5 inch (127 mm) vent}
\]

From Table 803.1.2(2), select 6 inches (152 mm) vent.

\[
186,000 \text{ Btu/h (54.5 kW) } \times 0.90 = 167,000 \text{ Btu/h (49 kW)}
\]

This figure is exceeding the required 120,000 Btu/h (35 kW). Therefore, use a 6 inch (152 mm) vent and connector where three elbows are used.

FIGURE FG 101.2(14)
PRINCIPLES OF DESIGN OF MULTISTORY VENTS USING VENT CONNECTOR AND COMMON VENT DESIGN TABLES
[See Section 803.2.12 through Section 803.2.15]
**Example 2: Single Fan-Assisted Appliance.**

An installer has an 80 000 Btu/h (23.4 kW) input fan-assisted appliance that **shall** be installed using 10 feet (3048 mm) of lateral connector attached to a 30 foot (9144 mm) high Type B vent. Two 90-degree (1.57 rad) elbows are needed for the installation. **Can** a single-wall metal vent connector **be used** for this application? (See Figure F 101.4)

**Solution:**

Table 803.1.2(2) refers to the use of single-wall metal vent connectors with Type B vent. In the first column find the row associated with a 30 foot (9144 mm) height and a 10 foot (3048 mm) lateral. Read across this row, looking at the FAN Min and FAN Max columns, to find that a 3 inch (76 mm) diameter single-wall metal vent connector is not recommended. Moving to the next larger size single-wall connector [4 inch (102 mm)] we find that a 4 inch (102 mm) diameter single-wall metal connector has a recommended minimum vent capacity of 91 000 Btu/hr (26.7 kW) and a recommended maximum vent capacity of 144 000 Btu/hr (42 kW). The 80 000 Btu/hr (23.4 kW) fan-assisted appliance is outside this range, so the conclusion is that a single-wall metal vent connector **cannot be used** for this application using a 10 foot (3048 mm) of lateral for the connector. However, if the 80,000 Btu/hr (23.4 kW) input draft hood outlet that needs to be vented into a 12 foot (3658 mm) high Type B vent. The vent connector has a 5 foot (1524 mm) lateral length and is also Type B. **Can** this appliance **be vented** using a 4 inch (102 mm) diameter vent? (See Figure F 101.5)

**Solution:**

Table 803.1.2(1) is used in the case of an all Type B Vent system. However, since there is no entry in Table 803.1.2(1) does not have an entry for a height of 12 feet (3658 mm), and interpolation **shall** be used. Read down the 4 inch (102 mm) diameter NAT Max column to the row associated with a 10 foot (3048 mm) height and 5 foot (1524 mm) lateral to find the capacity value of 77 000 Btu/h (22.6 kW). Read further down to the 15 foot (4572 mm) height, 5 foot (1524 mm) lateral row to find the capacity value of 87 000 Btu/h (25.5 kW). The difference between the 15 foot (4572 mm) height capacity value and the 10 foot (3048 mm) height capacity value is 10 000 Btu/h (3 kW). The capacity for a vent system with a 12 foot (3658 mm) height is equal to the capacity for a 10 foot (3048 mm) height plus two-fifths of the difference between the 10 foot (3048 mm) and 15 foot (4572 mm) height values, or 77 000 Btu/h (22.6 kW) + 2/5 x 10 000 Btu/h (3 kW) = 81 000 Btu/h (23.7 kW). Therefore, a 4 inch (102 mm) diameter vent **can be used** in the installation.
**FG 102.0 Examples Using Common Venting Tables.**

**FG 102.1 Example 4: Common Venting Two Draft Hood-Equipped Appliances.** A 35 000 Btu/h (10.3 kW) water heater is to be common vented with a 150 000 Btu/h (44 kW) furnace, using a common vent with a total height of 30 feet (9144 mm). The connector rise is 2 feet (610 mm) for the water heater with a horizontal length of 4 feet (1219 mm). The connector rise for the furnace is 3 feet (914 mm) with a horizontal length of 8 feet (2438 mm). Assume single-wall metal connectors will be used with Type B vent. What size connectors and combined vent should be used in this installation? (See Figure FG 102.1)

Solution:

Table 803.2(2) should be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 803.2(2), find the row associated with a 30 foot (9144 mm) vent height. For a 2 foot (610 mm) rise on the vent connector for the water heater, read the shaded columns for draft hood-equipped appliances to find that a 3 inch (76 mm) diameter vent connector has a capacity of 37 000 Btu/h (10.8 kW). Therefore, a 3 inch (76 mm) single-wall metal vent connector should be used with the water heater. For a draft hood-equipped furnace with a 3 foot (914 mm) rise, read across the appropriate row to find that a 5 inch (127 mm) diameter vent connector has a maximum capacity of 120 000 Btu/h (35 kW) (which is too small for the furnace), and a 6 inch (152 mm) diameter vent connector has a maximum vent capacity of 172 000 Btu/h (50 kW). Therefore, a 6 inch (152 mm) diameter vent connector should be used with the 150 000 Btu/h (44 kW) furnace. Because both vent connector horizontal lengths are less than the maximum lengths listed in Section 803.2.1, the table values can be used without adjustments.

In the common vent capacity portion of Table 803.2(2), find the row associated with a 30 foot (9144 mm) vent height and read over to the NAT + NAT portion of the 6 inch (152 mm) diameter column to find a maximum combined capacity of 257 000 Btu/h (75 kW). Since the two appliances total only 185 000 Btu/h (54 kW), a 6 inch (152 mm) common vent can be used.

**FG 102.2 Example 5(a): Common Venting a Draft Hood-Equipped Water Heater with a Fan-Assisted Furnace into a Type B Vent.** In this case, a 35 000 Btu/h (10.3 kW) input draft hood-equipped water heater with a 4 inch (102 mm) diameter draft hood outlet, 2 feet (610 mm) of connector rise, and 4 feet (1219 mm) of horizontal length is to be common vented with a 100 000 Btu/h (29 kW) fan-assisted furnace with a 4 inch (102 mm) diameter flue collar, 3 feet (914 mm) of connector rise, and 6 feet (1829 mm) of horizontal length. The common vent consists of a 30 foot (9144 mm) height of Type B vent. What are the recommended vent diameters for each connector and the common vent? The installer would like to use a single-wall metal vent connector. (See Figure FG 102.2)

Solution:

Water Heater Vent Connector Diameter. Since the water heater vent connector horizontal length of 4 feet (1219 mm) is less than the maximum value listed in Table 803.2(2), the venting table values can be used without adjustments. Using the Vent Connector Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and read across the 2 feet (610 mm) Connector Rise (R) row to the first Btu/h rating in the NAT Max column that is equal to or exceeding greater than the water heater input rating. The table shows that a 3 inch (76 mm) vent connector has a maximum input rating of 37 000 Btu/h (10.8 kW). Although this rating is exceeding greater than the water heater input rating, a 3 inch (76 mm) vent connector is prohibited by Section 803.2.18. A 4 inch (102 mm) vent connector has a maximum input rating of 67 000 Btu/h (19.6 kW) and is equal to the draft hood outlet diameter. A 4 inch (102 mm) vent connector is selected. Since the water heater is equipped with a draft hood, there are no minimum input rating restrictions.

Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and across the 3 feet (914 mm) Connector Rise (R) row. Because the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/h rating exceeding greater than the furnace input rating. The 4 inch (102 mm) vent connector has a maximum input rating of 119 000 Btu/h (34.9 kW) and a minimum input rating of 85 000 Btu/h (24.9 kW).

The 100 000 Btu/h (29 kW) furnace in this example falls within this range, so a 4 inch (102 mm) connector shall be permitted. Since is adequate. Because the furnace vent connector horizontal length of 6 feet (1829 mm) is less than the maximum value listed in Section 803.2.1, the venting table values can be used without adjustment. When the furnace had an input rating of 80 000 Btu/h (23.4 kW), then a Type B vent connector shall would be needed in order to meet the minimum capacity limit.
Common Vent Diameter. The total input to the common vent is 135 000 Btu/h (40 kW). Using the Common Vent Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and across this row to find the smallest vent diameter that has a Btu/h rating equal to or exceeding greater than 135 000 Btu/h (40 kW). The 4 inch (102 mm) common vent has a capacity of 132 000 Btu/h (39 kW) and the 5 inch (127 mm) common vent has a capacity of 202 000 Btu/h (59 kW). Therefore, the 5 inch (127 mm) common vent shall be used in this example.

Solution: Assuming the same vent connector heights, laterals, and materials found in Example 5(a), what are the recommended vent connector diameters, and is this an acceptable installation?

Summary: In this example, the installer shall use a 4 inch (102 mm) diameter, single-wall metal vent connector for the water heater and a 4 inch (102 mm) diameter, single-wall metal vent connector for the furnace. The common vent shall be a 5 inch (127 mm) diameter Type B vent.

For SI units: 1 foot = 304.8 mm, 1000 British thermal units per hour = 0.293 kW

\[ \text{Combined capacity} \times \text{Total Vent Height} = \text{Common Vent Diameter} \]

\[ \text{Furnace Vent Connector Diameter. Using the Vent Connector Capacity portion of Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and across this row to find the smallest vent diameter that has a Btu/h rating equal to or exceeding greater than the water heater input rating. The table shows that a 4 inch (102 mm) vent connector has a maximum input of only 31 000 Btu/h (9 kW), while a 4 inch (102 mm) vent connector has a maximum input of 57 000 Btu/h (16.7 kW). A 4 inch (102 mm) vent connector shall be permitted.} \]

| Masonry Chimney. From Table 803.2(2), read down the Total Vent Height (H) column to 30 feet (9144 mm) and across this row to find the smallest vent diameter that has a Btu/h rating exceeding greater than the water heater input rating. The table shows that a 4 inch (102 mm) vent connector has a maximum input rating of 127 000 Btu/h (37 kW) and an minimum input rating of not less than 95 000 Btu/h (27.8 kW). The 100 000 Btu/h (29 kW) furnace in this example falls within this range, so a 4 inch (102 mm) vent connector shall be permitted.]

Section 803.2.17 requires the common vent area to not exceed be no greater than seven times the smallest listed appliance categorized vent area, flue collar area, or draft hood outlet area. Both appliances in this installation have 4 inch (102 mm) diameter outlets. From Table 803.2(2), the equivalent area for an inside diameter of 4 inches (102 mm) is 12.2 of a square inches (0.008 m²). Seven times 12.2 equals 85.4, which is exceeding greater than 63.6, so this configuration is acceptable.

\[ \text{FG 102.4 Example 5(c): Common Venting into an Exterior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Examples 5(a) and 5(b) are to be common-vent into an exterior masonry chimney. The chimney height, clay-tile-liner dimensions, and vent connector heights and laterals are the same as in Example 5(b). This system is being installed in Charlotte, North Carolina. Does the exterior masonry chimney need to be relined? If so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended? [see Table 803.2(4) and Figure 803.1.2(6)] } \]

Solution:

According to Section 803.2.20, Type B vent connectors are required to be used with exterior masonry chimneys. Use Table 803.2(8) and Table 803.2(9) to size FAN+NA T common venting installations involving Type-B double-wall connectors into exterior masonry chimneys.

The local 99 percent winter design temperature needed to use Table 803.2(8) and Table 803.2(9) can be found in ASHRAE Handbook – Fundamentals. For Charlotte, North Carolina, this design temperature is 19°F (-7.2°C).
Chimney Liner Requirement. As in Example 5(b), use the 63 square inch (0.04 m²) internal area columns for this size clay tile liner. Read down the 63 square inches (0.04 m²) column of Table 803.2(8) to the 30 foot (9144 mm) height row to find that the combined appliance maximum input is 747 000 Btu/h (218.9 kW). The combined input rating of the appliances in this installation, 135 000 Btu/h (40 kW), is less than the maximum value, so this criterion is satisfied. Table 803.2(9), at a 19°F (-7.2°C) design temperature, and at the same vent height and internal area used earlier, shows that the minimum allowable input rating of a space-heating appliance is 470 000 Btu/h (137.7 kW). The furnace input rating of 100 000 Btu/h (29 kW) is less than this minimum value. So this criterion is not satisfied, and an alternative venting design needs to be used, such as a Type B vent shown in Example 5(a) or a listed chimney liner system shown in the remainder of the example.

According to Section 803.2.19, Table 803.2(1) or Table 803.2(2) is used for sizing corrugated metallic liners in masonry chimneys, with the maximum common vent capacities reduced by 20 percent. This example will be continued assuming Type B vent connectors.

Water Heater Vent Connector Diameter. Using Table 803.2(1) Vent Connector Capacity, read down the total Vent Height (H) column to 30 feet (9144 mm), and read across the 2 feet (610 mm) Connector Rise (R) row to the first Btu/hour rating in the NAT Max column that is equal to or greater than the water heater input rating. The table shows that a 3 inch (76 mm) vent connector has a maximum capacity of 39 000 Btu/h (11.4 kW). Although this rating is greater than the water heater input rating, a 3 inch (76 mm) vent connector is prohibited by Section 803.2.20. A 4 inch (102 mm) vent connector has a maximum input rating of 70 000 Btu/h (20.5 kW).

### Table FG 102.3

<table>
<thead>
<tr>
<th>NOMINAL LINER SIZE (Inches)</th>
<th>INSIDE DIMENSIONS OF LINER (Inches)</th>
<th>INSIDE DIAMETER OR EQUIVALENT DIAMETER (Inches)</th>
<th>EQUIVALENT AREA (Square Inches)</th>
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For SI units, 1 inch = 25.4 mm, 1 square inch = 0.000645 m²

* Where liner sizes differ dimensionally from those shown in this table, equivalent diameters shall be permitted to be determined from published tables for square and rectangular ducts of equivalent carrying capacity or by other engineering methods.
and is equal to the draft hood outlet diameter. A 4 inch (102 mm) vent connector is selected.

Furnace Vent Connector Diameter. Using Table 803.2(1), Vent Connector Capacity, read down the total Vent Height (H) column to 30 feet (9144 mm), and read across the 3 feet (914 mm) Connector Rise (R) row to the first Btu/h rating in the FAN MAX column that is equal to or greater than the furnace input rating. The 100 000 Btu/h (29 kW) furnace in this example falls within this range, so a 4 inch (102 mm) connector is adequate.

Chimney Liner Diameter. The total input to the common vent is 135 000 Btu/h (40 kW). Using the Common Vent Capacity portion of Table 803.2(1), read down the total Vent Height (H) column to 30 feet (9144 mm) and across this row to find the smallest vent diameter in the FAN + NAT column that has a Btu/h rating greater than 135 000 Btu/h (40 kW). The 4 inch (102 mm) common vent has a capacity of 138 000 Btu/h (40.4 kW). Reducing the maximum capacity by 20 percent results in a maximum capacity for a 4 inch (102 mm) corrugated liner of 110 000 Btu/h (32 kW), less than the total input of 135 000 Btu/h (40 kW). So a larger liner is needed. The 5 inch (127 mm) common vent capacity listed in Table 803.2(1) is 210 000 Btu/h (62 kW), and after reducing by 20 percent is 168 000 Btu/h (49.2 kW). Therefore, a 5 inch (127 mm) corrugated metal liner should be used in this example.

Single Wall Connectors. Once it has been established that relining the chimney is necessary, Type B double-wall vent connectors are not specifically required. This example could be redone using Table 803.2(2) for single-wall vent connectors. For this case, the vent connector and liner diameters would be the same as found for Type B double-wall connectors.

**FG 103.0 Example of Combination Indoor and Outdoor Combustion Air Opening Design.** Determine the required combination of indoor and outdoor combustion air opening sizes for the following appliance installation example.

Example Installation: A fan-assisted furnace and a draft hood-equipped water heater with the following inputs are located in a 15 foot by 30 foot (4572 mm by 9144 mm) basement with an 8 foot (2438 mm) ceiling. No additional indoor spaces shall be used to help meet the appliance combustion air needs.

Fan-Assisted Furnace Input: 100 000 Btu/h (29 kW)
Draft Hood-Equipped Water Heater Input: 40 000 Btu/h (11.7 kW)

Solution:
1. Determine the total available room volume.
   - Appliance room volume.
   - 15 feet by 30 feet (4572 mm by 9144 mm) with an 8 foot (2438 mm) ceiling = 3600 cubic feet (101.94 m³)

2. Determine the total required volume.
   - The Standard Method to determine combustion air shall be used to calculate the required volume.
   - The combined input for the appliances located in the basement is calculated as follows:
     - 100 000 Btu/h (29 kW) + 40 000 Btu/h (11.7 kW) = 140 000 Btu/h (41 kW)
   - The Standard Method requires that the required volume be determined based on 50 cubic feet per 1000 Btu/h (4.83 m³/kW).
   - Using Table FG 103.0 the required volume for a 140 000 Btu/h (41 kW) water heater is 7000 cubic feet (198.22 m³).

Conclusion:
- The indoor volume is insufficient to supply combustion air since the total of 3600 cubic feet (101.94 m³) does not meet the required volume of 7000 cubic feet (198.22 m³). Therefore, additional combustion air shall be provided from the outdoors.

3. Determine the ratio of the available volume to the required volume:
   \[
   \frac{3600 \text{ cubic feet}}{7000 \text{ cubic feet}} = 0.51
   \]

4. Determine the reduction factor to be used to reduce the full outdoor air opening size to the minimum required based on ratio of indoor spaces:
   \[
   1.00 - 0.51 \text{ (from Step 3)} = 0.49
   \]

5. Determine the single outdoor combustion air opening size as if all combustion air is to come from outdoors. In this example, the combustion air directly communicates with the outdoors:
   \[
   \frac{140 000 \text{ Btu/h}}{3000 \text{ British thermal units per square inch (Btu/in²)}} = 47 \text{ square inches (0.03 m²)}
   \]

6. Determine the minimum outdoor combustion air opening area:
   \[
   \text{Outdoor opening area} = 0.49 \text{ (from Step 4)} \times 47 \text{ square inches (0.03 m²)}
   \]
   \[
   = 23 \text{ square inches (0.01 m²)}
   \]

Section 701.7.3(3) requires the minimum dimension of the air opening shall be not less than 3 inches (76 mm).
APPENDIX G

TABLE EQ 103.0
STANDARD METHOD: REQUIRED VOLUME, ALL APPLIANCES
[NFPA 54: TABLE A.9.3.2.1]

<table>
<thead>
<tr>
<th>APPLIANCE INPUT (Btu/h)</th>
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<td>250</td>
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<tr>
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<tr>
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<td>14 500</td>
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<td>300 000</td>
<td>15 000</td>
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</table>

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 cubic foot = 0.0283 m³
Example Calculation of Outdoor Air Rate.

**APPENDIX GH**

**EXAMPLE CALCULATION OF OUTDOOR AIR RATE**

**GH 101.0 Example Calculation of Outdoor Air Rate.**

**GH 101.1 Example Calculation.** Determine the outdoor air rate required for a single zone AC unit serving an interior 2000 square feet (185.81 m²) conference/meeting room with a design occupancy of 100 people. The system supplies and returns air from the ceiling. (See Chapter 4 of this code for guidelines)

Solution:

In accordance with Table 403.2.2, the zone air distribution effectiveness is 1.0 since the system supplies cooling only from the ceiling. Using the rates from Table 402.1 for a conference/meeting room, the minimum system outdoor air rate is calculated to be:

\[
V_{ot} = \frac{R_p P_z + R_a A_z}{E_z} \quad \text{(Equation GH 101.1)}
\]

\[
= \frac{5 \times 100 + 0.06 \times 2000}{1.0}
\]

\[
= 620 \text{ cubic feet per minute (ft}^3/\text{min)}
\]

Where:

- \( A_z \) = zone floor area: the net occupiable floor area of the zone in square feet.
- \( P_z \) = zone population: The largest number of people expected to occupy the zone during typical usage. Where the number of people expected to occupy the zone fluctuates, \( P_z \) shall be permitted to be estimated based on averaging approaches described in Section 403.6.1. Where \( P_z \) cannot be accurately predicted during design, it shall be estimated based on the zone floor area and the default occupant density in accordance with Table 402.1.
- \( R_p \) = outdoor airflow rate required per person in accordance with Table 402.1.
- \( R_a \) = outdoor airflow rate required per unit area in accordance with Table 402.1.
- \( E_z \) = zone air distribution effectiveness in accordance with Table 403.2.2.

For SI units: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.00047 m³/s
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Note: Contents and Section numbers will be updated before publishing.

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WARM AIR FURNACE
Definition .......................................................... 225.0
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WATER HEATERS
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