2014 REPORT ON COMMENTS


2014 ASSOCIATION TECHNICAL MEETING CONVENTION

Hilton Minneapolis
Minneapolis, Minnesota
September 14 - 18, 2014
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](http://www.iapmo.org).

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

2. **Technical Committee Report (TCR).** The Technical Committee Report is defined as the Report of the Technical Committee 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 29-October 3, 2013, in Kansas City, Missouri. The Assembly Consideration Session is scheduled for October 1, 2013. 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 constitute 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 14-18, 2014, in Minneapolis, Minnesota. 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 2014

Enclosed is your 2014 Report on Comments (ROC).

These comments were presented to the Mechanical Technical Committee who met in Las Vegas, Nevada on April 30 – May 1, 2014.

At the Annual Education and Business Conference to be held September 14 – 18, 2014, in Minneapolis, Minnesota, IAPMO members and others attending the convention will have the opportunity to discuss and debate these comments. The IAPMO voting membership present at that conference will then vote on the actions taken by the Technical Committee.

Following the comments is a copy of how the 2015 edition of the Uniform Mechanical Code (pre-print) would appear if all committee actions are accepted by the membership.

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 2015 Uniform Mechanical Code. Specific authorization from IAPMO is required for republication or quotation.

THE BALLOT RESULTS ON ALL COMMITTEE ACTIONS ON COMMENTS PASSED EXCEPT FOR THE FOLLOWING TWO ACTIONS:

ITEM 102 FAILED TO ACHIEVE THE NECESSARY 2/3 AFFIRMATIVE VOTE OF RETURNED BALLOTS.
ITEM 341 Com 2 FAILED TO ACHIEVE THE NECESSARY 2/3 AFFIRMATIVE VOTE OF RETURNED BALLOTS.

In accordance with Section 4-4.6.4 where the technical committee actions failed to achieve the necessary 2/3 affirmative vote, the technical committee action on the public comment shall be reported in the ROC as rejected.
# MECHANICAL TECHNICAL COMMITTEE
(as of 03/26/14)

<table>
<thead>
<tr>
<th>NAME</th>
<th>REPRESENTATION</th>
<th>CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>April Trafton, Chairperson</td>
<td>American Society of Plumbing Engineers</td>
<td>Special Expert</td>
</tr>
<tr>
<td>Anthony Scarano</td>
<td>Plastic Piping Consultant</td>
<td>Special Expert</td>
</tr>
<tr>
<td>Leonard A. Ramociotti</td>
<td>LAR Consulting</td>
<td>Special Expert</td>
</tr>
<tr>
<td>Phil Ribbs</td>
<td>PHR Consultants</td>
<td>Special Expert</td>
</tr>
<tr>
<td>Gary Hile, Ex-Officio*</td>
<td>IAPMO</td>
<td>Enforcing Authority</td>
</tr>
<tr>
<td>Osama Younan, Principal Mark Casey, Alternate</td>
<td>City of Los Angeles – Department of Building and Safety</td>
<td>Enforcing Authority</td>
</tr>
<tr>
<td>Bob Adler, Principal Steven Panelli, Alternate</td>
<td>City of San Jose, California City &amp; County of San Francisco, California</td>
<td>Enforcing Authority</td>
</tr>
<tr>
<td>Roel Garcia</td>
<td>City of Houston</td>
<td>Enforcing Authority</td>
</tr>
<tr>
<td>Jerry Garza</td>
<td>Jerry Garza &amp; Associates</td>
<td>User</td>
</tr>
<tr>
<td>Paul Cabot</td>
<td>American Gas Association</td>
<td>User</td>
</tr>
<tr>
<td>Steven Taylor</td>
<td>American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)</td>
<td>User</td>
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<td>Dan Buuck, Principal Cai Owens, Alternate</td>
<td>National Association of Home Builders</td>
<td>User</td>
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<tr>
<td>James Pavesic, Principal Phil Campbell, Alternate</td>
<td>United Association</td>
<td>Labor</td>
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<td>David Dias, Principal Erik Emblem, Alternate</td>
<td>Sheet Metal Workers Local 104 Western States Council of Sheet Metal Workers IA</td>
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<td>DJ Berger, Principal TJ Dodd, Alternate</td>
<td>New Orleans Pipe Trades Austin Area Plumbing &amp; Pipe Fitters JATC</td>
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<tr>
<td>David Mann, Principal Che Timmons, Alternate</td>
<td>CA State Pipe Trades Local 342</td>
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<tr>
<td>Ian Chang</td>
<td>Intertek Testing Services</td>
<td>Research/Standards/Test Laboratory</td>
</tr>
<tr>
<td>Denise Beach*</td>
<td>NFPA</td>
<td>Research/Standards/Test Laboratory</td>
</tr>
<tr>
<td>Maggie Carroll, Principal James Dingman, Alternate</td>
<td>Underwriters Laboratories</td>
<td>Research/Standards/Test Laboratory</td>
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<td>Richard Church, Principal Michael Cudahy, Alternate</td>
<td>Plastic Pipe &amp; Fittings Association</td>
<td>Manufacturer</td>
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<td>Pennie Feehan</td>
<td>Copper Development Association</td>
<td>Manufacturer</td>
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<td>Tim Orris, Principal Vickie Lovell, Alternate</td>
<td>Air Movement and Control Association International, Inc.</td>
<td>Manufacturer</td>
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<tr>
<td>Bob Wiseman, Principal Luis Escobar, Alternate</td>
<td>Air Conditioning Contractors of America</td>
<td>Installer/Maintainer</td>
</tr>
<tr>
<td>Harvey Kreitenberg</td>
<td>Harvey Kreitenberg &amp; Associates</td>
<td>Installer/Maintainer</td>
</tr>
<tr>
<td>Hugo Aguilar, Staff Liaison</td>
<td>IAPMO Staff</td>
<td></td>
</tr>
</tbody>
</table>

Total Voting Members: 22
*Total Non-Voting Members: 2

The above listed TC Members are in order of classification (see far right column).
IAPMO Technical Committee Membership Application

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

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

Please indicate committee for which you are applying:

☐ Plumbing Technical Committee  ☐ Swimming Pool, Spa and Hot Tub Technical Committee
☐ Mechanical Technical Committee  ☐ Solar Energy Code Technical Committee

Member categories:

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

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

☐ Manufacturer  ☐ Research/Standards/Testing Laboratory
☐ User  ☐ Enforcing Authority
☐ Installer/Maintainer  ☐ Consumer
☐ Labor  ☐ Special Expert

1. QUALIFICATIONS OF APPLICANT
   a. Provide evidence of your general knowledge and competence in the scope (work) of the committee (please attach résumé)
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   b. What is your specific relationship to one or more elements of the scope of the committee?
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   c. Will you be able to actively participate in the work of the committee including responding to correspondence and attending committee meetings?
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   __________________________________________________________________________________________

2. REPRESENTATION  Indicate below the name of the entity you would be representing and include written authorization from that entity authorizing you to be their representative:
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   __________________________________________________________________________________________
   a. Does the organization you would represent have a mechanism for instructing votes? If so, can the time constraints imposed by the Regulations Governing Committee Projects be met?
   __________________________________________________________________________________________
   __________________________________________________________________________________________
3. **FUNDING SOURCE(S) FOR YOUR PARTICIPATION**
   
a. What person(s) or organization(s) would fund your participation as a committee member, either in whole or in part? (You should list your employer if your participation is funded by your employer or if your participation is part of your employment responsibilities or otherwise related to your employment.)
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________

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

4. **ADDITIONAL COMMENTS**
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________

Languages other than English ____________________________

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

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

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

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

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

Signature ____________________________ Date___________________________

**INTEREST CATEGORIES**

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

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

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

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

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

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

(g) **Consumer.** A person who is or represents the ultimate purchaser of a product, system or service affected by the Document but who is not a User as defined in 3-2.5.1(b).

(h) **Special Expert.** A person not representing 3-2.5.1(a) through (g) and who has special expertise in the scope of the Document or portion thereof.
The Association Technical Meetings are an important step in developing a complete record to assist the IAPMO Standards Council in determining the degree of consensus achieved. These convention rules, or any part of same, may not be suspended. The transaction of business at Association Technical Meetings shall be governed, in order of precedence, by the Regulations Governing Committee Projects (see especially section 4-5) and these Convention Rules.

1. **Meetings.** The Secretary of the Standards Council shall develop and publish in advance, an agenda for each Association Technical Meeting. 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 Definitely.** Not allowed.

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

11. **Amending Motions.** See Regulations Governing Committee Projects at section 4-5 (especially 4-5.4 through 4-5.8).

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 motion that the vote be counted is allowed and requires a majority vote of those present.

14. **Main Motion (not applicable).** All motions have been submitted prior to sessions as per Regulations Governing Committee Projects and program.

15. **Point of Order.** Allowed.

16. **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 IAPMO Standards Council.

17. **Suspend Rules.** Not allowed.

18. **Division of Question.** Allowable at the discretion of the chair.

19. **Division of Assembly.** Not allowed (see paragraph 14).

20. **Parliamentary Inquiry or Point of Information.** Allowed.

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

22. **Take from the Table.** Not allowed.

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

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

25. **Reconsider, Rescind, or Amend Something Previously Adopted.** Applicable only within the period of discussion of the specific document and prior to the final vote.
One of the many benefits of the IAPMO consensus code development process is the ability for anyone and everyone to have a voice. The Plumbing and Mechanical Technical Committees have collectively reviewed and responded to over 398 proposed comments to the 2015 editions of the *Uniform Plumbing Code* and *Uniform Mechanical Code*. Their ballot results are provided to you in the *Report on Comments* (ROC).

During our Annual Education and Business Conference, we will be conducting the Association Technical Meeting Convention. This is an essential opportunity to advocate your position in accordance with any of the following technical committee reports and motions.

The session will be conducted as follows:
1. The Moderator will review the rules at the start of the session.
2. The Moderator will remind everyone that all discussions will be based on actions taken by the Plumbing and Mechanical Technical Committees, as published in the *Report on Comments* and *Report on Proposals*. Each participant should come prepared with a copy of both the *UPC* and *UMC Report on Comments* and *Report on Proposals*.
3. The Technical Meeting Convention on the *Uniform Plumbing Code* and the for the *Uniform Mechanical Code* sessions will take place on Tuesday, September 16, 2014. At the start of the sessions, the Moderator will call for motions starting with Chapter 1 and continue in the numerical order of chapters and conclude with the Appendices. A motion may be made to any item located in the ROP or ROC. At the conclusion of the session, we will call for any remaining motions related to the respective code.
4. Any person who has submitted a proposal or comment may make a motion (or a specifically designated representative in advance). Additionally, anyone can make a motion if there was a modification in the ROC. Motions that are in order consisting of suggested revisions to the proposals or comments must be returned to the Technical Committee for further study or statement for the record. **A person making the motion must fill out a card with correct information prior to the start of the meeting.**

Motions on proposals from the ROP are as follows:
- Accept the proposed code change as published in the ROP.
- Accept an identifiable part of the proposed code change proposal. The motion changes the text in accordance with the identifiable part of the proposal as published in the ROP.
- Accept as modified by the Technical Committee. The motion changes the text in accordance with the identifiable part of the proposal (as modified by the TC) as published in the ROP.
- Accept an identifiable part of the proposed code change proposal as modified by the TC. The motion changes the text in accordance with the identifiable part of the proposal (as modified by the TC) as published in the ROP.

### ROP MOTIONS

<table>
<thead>
<tr>
<th>Committee Action</th>
<th>Assembly Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS (Accept proposal as submitted)</td>
<td>Accept an Identifiable Part.</td>
</tr>
<tr>
<td>If you disagree with the committee’s action, you will be permitted to make a motion to:</td>
<td></td>
</tr>
<tr>
<td>AM (Accept proposal as amended by TC)</td>
<td>Accept the Proposed Code Change as Submitted;</td>
</tr>
<tr>
<td>If you disagree with the committee’s action, you will be permitted to make a motion to:</td>
<td>Accept an Identifiable Part; or</td>
</tr>
<tr>
<td>R (Reject the proposal)</td>
<td>Accept the Proposed Code Change as Submitted; or</td>
</tr>
<tr>
<td>If you disagree with the committee’s action, you will be permitted to make a motion to:</td>
<td>Accept an Identifiable Part</td>
</tr>
</tbody>
</table>
Motions on proposals from the ROC are as follows:

(a) Accept the comment. The motion changes the text in accordance with the comment as published in the ROC.
(b) Accept an identifiable part of the proposed public comment. The motion changes the text in accordance with the identifiable part of the comment as published in the ROC.
(c) Accept a comment as modified by the Technical Committee. The motion changes the text in accordance with the committee action on the comment as published in the ROC.
(d) Accept an identifiable part of the public comment as modified by the Technical Committee. The motion changes the text in accordance with the identifiable part of the comment as published in the ROC.
(e) Reject the comment. The motion returns that portion to ROP text.
(f) Reject an identifiable part of a comment. The motion returns that portion to ROP text.

### ROC MOTIONS

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<thead>
<tr>
<th>Committee Action</th>
<th>Assembly Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS (Accept the comment as submitted)</td>
<td>Accept an Identifiable Part of the Comment;</td>
</tr>
<tr>
<td>If you disagree with the committee’s action, you will be permitted to make a motion to:</td>
<td>Reject the Comment; or</td>
</tr>
<tr>
<td></td>
<td>Reject an Identifiable Part of the Comment.</td>
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<tr>
<td>AM (Accept the comment as amended by TC)</td>
<td>Accept the comment as submitted;</td>
</tr>
<tr>
<td>If you disagree with the committee’s action, you will be permitted to make a motion to:</td>
<td>Accept an Identifiable Part of the Comment;</td>
</tr>
<tr>
<td></td>
<td>Accept an Identifiable Part of the Comment as Modified by the TC;</td>
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<tr>
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<td>Reject the Comment; or</td>
</tr>
<tr>
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<td>Reject an Identifiable Part of the Comment.</td>
</tr>
<tr>
<td>R (Reject the comment)</td>
<td>Accept the comment as submitted;</td>
</tr>
<tr>
<td>If you disagree with the committee’s action, you will be permitted to make a motion to:</td>
<td>Accept an Identifiable Part of the Comment;</td>
</tr>
<tr>
<td></td>
<td>Accept an Identifiable Part of the Comment.</td>
</tr>
</tbody>
</table>

For those of you who are planning to make a motion during the session, please state (your) name and affiliation; clearly state the motion (proposal or comment number with the page number in the ROP or ROC) and wait for moderator to acknowledge. Once the Moderator has recognized the second, proceed with discussion. For discussion purposes, please keep the information simple and to the point, and provide any applicable references to statements and ballots in the ROP or ROC. Audio and visual presentations are prohibited. Please present any handouts to IAPMO staff for approval. IAPMO staff will be available Tuesday, September 16 from 7:30am – 8:30 am in order to assist members making motions.

The 2014 Annual Education and Business Conference will be held from September 14 - 18, 2014 in Minneapolis, Minnesota. For more information on the event, please visit our web site at [www.iapmo.org](http://www.iapmo.org) or contact the following:

- Hugo Aguilar, Mechanical Code Administrator at (909) 472-4111 or at Hugo.Aguilar@iapmo.org
- Enrique Gonzalez, Plumbing Code Administrator at 909-230-5535 or at Enrique.Gonzalez@iapmo.org

We look forward to seeing you in Minneapolis!
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**Task Group Report**

Technical Correlating Committee Report

**2014 Uniform Mechanical Code Preprint**

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by

International Association of Plumbing and Mechanical Officials

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SUBMITTER: Dave Levanger
Chair, Technical Correlating Committee (TCC) (see TCC Report Items # 13, 14, 15)

RECOMMENDATION:
Revise text as follows:

203.0
Accessible. Where applied to a device, appliance, or equipment, “accessible” means having access thereto, but which that first may requires the removal of an access panel, door, or similar obstruction covering the item described.

Appliance Categorized Vent Diameter/Area. The minimum vent area/diameter permissible for Category I appliances to maintain a nonpositive vent static pressure where tested in accordance with nationally recognized standards. [NFPA 54:3.3.7]

205.0
Chimney. A vertical shaft enclosing one or more flues. 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 terms of listing manufacturer’s installation instructions to form the completed chimney. [NFPA 54:3.3.18.2]

Combustible Material. Material subject to an increase in combustibility or flame-spread rating beyond the limits established in the definition of Limited-Combustible Material. As pertaining to materials adjacent to or in contact with heat-producing appliances, vent connectors, gas vents, chimneys, steam and hot water pipes, and warm air ducts, materials made of or surfaced with wood, compressed paper, plant fibers, or other materials that are capable of being ignited and burned. Such material shall be considered combustible even though flame-proofed, fire-retardant treated, or plastered. [NFPA 54:3.3.67.1]

SUBSTANTIATION:
1. The definition for “Accessible” is being revised to correlate with the UPC.
2. The definition for “Appliance Categorized Vent Diameter/Area” is being added as the term is used in Sections 803.1.14 and 803.2.20. This definition also correlates with the UPC and NFPA 54-2012.
3. The definition for “Chimney” and “Chimney Factory-Built” are being revised to correlate with NFPA 54-2012.
4. The definition for “Combustible Material” is being revised to correlate with the UPC and NFPA 54-2012.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

Accessible. Where applied to a device, appliance, or equipment, “accessible” means having access thereto, but which that first may requires the removal of an access panel, door, or similar obstruction.

COMMITTEE STATEMENT:
The committee felt that the proposed revision for “accessible” is in conflict with the definition for “readily accessible.” Therefore, the definition was modified to correlate with the 2012 UPC.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 015 “Appliance” resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:
Appliance. A device that utilizes an energy source to produce light, heat, power, refrigeration, or air-conditioning. This definition also shall include a vented decorative appliance.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revisions to the definition for “appliance” of the UMC will correlate with actions taken by the UPC TC to “accept as amend” Item # 015.

The reason provided by the UPC TC for “accepting as amended” Item # 015 is as follows: For the definition of “appliance,” changing the term to “energy source” is in keeping with the accepted terminology used throughout the industry.

The following proposed action moves forward as approved by the TCC and supersedes any recommendation from the UMC TC.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates
RECOMMENDATION: Request to accept the code change proposal as modified by this public comment.

203.0 Accepted Engineering Practice. That which conforms to technical or scientific-based principles, tests, or standards that are accepted by the engineering profession.

SUBSTANTIATION:
The definition for “accepted engineering practice” is necessary as it is addressed in Sections 309.1, 1308.7.5.1, and D 13.1 without being defined. The proposed definition assists the end user in applying and enforcing this term. This definition is also consistent with what was approved for the UPC.

COMMITTEE ACTION: Reject the public comment
COMMITTEE STATEMENT:
The proposed definition for “accepted engineering practice” has not had a public review as it introduces a new concept which was not included in a related proposal as published in the ROP.

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 013 and UPC Item # 016 resulted in a con-
lict within this code in regards to the definition for “accepted engineering practice.” In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

203.0

**Accepted Engineering Practice.** That which conforms to technical or scientific-based principles, tests, or standards that are accepted by the engineering profession.

**TCC COMMITTEE ACTION:** Accept as Submitted

**TCC COMMITTEE STATEMENT:**
The new definition for “accepted engineering practice” of the UMC will correlate with actions taken by the UPC TC to “accept as amended by the TC” Item # 016. Furthermore, it will correlate with the actions taken by the USPSHTC to “accept as submitted” Item # 004.

The definition for “accepted engineering practice” is addressed in Section 309.1, Section 1308.7.5.1, and Section D 13.1 of the UMC without being defined. The proposed definition assists the end user in applying and enforcing this term.

The substantiation provided by the UPC for accepting Item # 016 as submitted is as follows: “The term “accepted engineering practice” is used in Sections 309.1, 501.1, 911.1, 1208.7.5.1, 1314.1, and E 35.1 without being defined. The proposed definition assists the end user in applying and enforcing this term, and is consistent with terminology used in other industry standards.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on the public comment Item # 013 in regards to the definition for “accepted engineering practice.”
205.0 Condensate. A liquid that separates from a gas (including flue gas) due to a reduction in temperature or an increase in pressure.

SUBSTANTIATION:
The term “condensate” is used throughout the UMC and needs a definition.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

205.0 Condensate. A liquid obtained from condensation of a gas or vapor (including flue gas) due to a reduction in temperature or an increase in pressure.

COMMITTEE STATEMENT:
The language was modified to match the term with how it is understood throughout the industry.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:

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

205.0 Condensate. A liquid obtained from by condensation of a gas or vapor.

SUBSTANTIATION:
The definition for “condensate” should be revised since condensate is obtained by the condensation and not from a gas or vapor. Furthermore, the revisions will be consistent with the definition found in the dictionary.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

205.0 Condensate. The liquid phase produced obtained by condensation of a particular gas or vapor.

COMMITTEE STATEMENT:
The proposed modification will provide clarity in regards to the definition for “condensate.”
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
TAYLOR: There is no definition needed for “condensate.”

EXPLANATION OF NEGATIVE:
FEEHAN: The revised definition is confusing. I prefer the original public comment.
Item # 027
UMC 2015 – (219.0):

SUBMITTER: Jayendra S. Parikh
Compliance Solutions International Inc.

RECOMMENDATION:
Revise text as follows:

219.0
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. [NFPA 96:3.3.41]

SUBSTANTIATION:
The term “or company” should be deleted, since a person meets the requirements and training for a given field, not a company, and the definition of “Trained” (in Section 222.0) mentions a “person” and not a “company.”

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The term “or company” is required as some jurisdictions may require both the person and the company to be qualified.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

219.0
Qualified. A competent and capable person who has met the requirements and training for a given field acceptable to the Authority Having Jurisdiction. [NFPA 96:3.3.40]

SUBSTANTIATION:
The definition for “qualified” should be modified to correlate with NFPA 96-2014 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 12)

RECOMMENDATION:
Revise text as follows:

303.4 Unlisted Appliances. Except as otherwise provided in this code, unlisted appliances shall be installed in accordance with the manufacturer’s installation instructions and with the standard clearances from combustible in accordance with Section 303.10 or Section 303.10.1 construction specified in Table 303.4. Unlisted appliances shall have the standard clearances of Table 303.4 reduced by employing the forms of protection specified in Table 303.3(1). Forms of protection specified in Table 303.3(1) shall be permitted to be utilized to reduce clearances to combustible construction for applicable appliances.

303.10 Clearances. Where not provided in this code, listed and unlisted equipment and appliances shall be installed to maintain the required clearances for servicing and to combustible construction in accordance with the manufacturer’s installation instructions.

303.10.1 Clearance Reduction. Where permitted by the manufacturer, reduce clearances to combustible construction for listed equipment and appliances shall comply with Table 303.10.1. 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.

TABLE 303.3(1)
CLEARANCES, IN INCHES, WITH SPECIFIED FORMS OF PROTECTION

TABLE 303.4
STANDARD INSTALLATION CLEARANCES IN INCHES FOR UNLISTED HEAT-PRODUCING APPLIANCES

TABLE 802.7.3.4(2) 303.10.1
REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION

(portions of table not shown remain unchanged)

Notes:
1 – 3 (remaining text unchanged)
4 Where clearance reduction systems use a ventilated air space, a provision for air circulation shall be provided as described. [See Figure 904.2(2) 303.10.1(2) and Figure 904.2(3) 303.10.1(3)]
5 – 11 (remaining text unchanged)

FIGURE 904.2(1) 303.10.1(1)
EXTENT OF PROTECTION NECESSARY TO REDUCE CLEARANCES FROM GAS APPLIANCES OR VENT CONNECTORS
[NFPA 54: FIGURE 10.3.2.2(a)]

(portions of figure not shown remain unchanged)
Notes:

1 A – Equals the clearance with no protection specified in Table 802.7.3.4(1) and Table 904.2 and in the sections applying to various types of appliances.

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 904.2(2) 303.10.1(2)
WALL PROTECTOR CLEARANCE REDUCTION SYSTEM
[NFPA 54: FIGURE 10.3.2.2(b)]

(portions of figure not shown remain unchanged)

FIGURE 904.2(3) 303.10.1(3)
MASONRY CLEARANCE REDUCTION SYSTEM
[NFPA 54: FIGURE 10.3.2.2(c)]

(portions of figure not shown remain unchanged)

FIGURE 303.3
EXTENT OF PROTECTION REQUIRED TO REDUCE CLEARANCES FROM APPLIANCE, CHIMNEY, OR VENT CONNECTORS
[NFPA 211: FIGURE 9.6.1-1]

506.7 Duct Clearances. Ductwork and system components handling combustible material and operating at less than 140°F (60°C) shall have a clearance of not less than 18 inches (457 mm) from combustible construction or a combustible material. [NFPA 91:4.6.2]

Exceptions:
(1) Where the ductwork system is equipped with an approved automatic extinguishing system designed for the specific hazard, the clearance shall be permitted to be reduced to 6 inches (152 mm) from combustible materials and ½ of an inch (12.7 mm) from combustible construction. [NFPA 91:4.6.2.1]

(2) Where the combustible material and construction is protected by the use of materials or products listed for protection purposes or in accordance with Table 506.7 303.10.1.

506.7.5 Clearance with Wall Protector/Surface. There shall be not less than 1 inch (25.4 mm) between the duct and the wall protector. In no case shall the clearance between the duct and the wall surface be reduced below that shown in Table 506.7 303.10.1.

TABLE 506.7
REDUCTION OF DUCT CLEARANCE WITH SPECIFIED FORMS OF PROTECTION
[NFPA 91: TABLE 4.6.4]

FIGURE 506.7
EXTENT OF PROTECTION REQUIRED TO REDUCE CLEARANCES FROM DUCTS
[NFPA 91: FIGURE 4.6.5.1]

SUBSTANTIATION:
1. Section 303.4 is being revised since the installation of unlisted equipment and appliances should be installed in accordance with the manufacturer’s installation instructions, except as otherwise indicated in the code. Furthermore, a reference to new Section 303.10 is being added to refer the end user to the necessary clearance requirements.
2. Table 303.3(1) and Table 303.4 are being deleted since clearances should be in accordance with the manufacturer’s instructions, except as otherwise provided in the code for both listed and unlisted equipment and appliances. Furthermore, the sources of the tables are not known and cannot be verified for accuracy. Therefore, all references are being made to NFPA 54 to safeguard and public health and safety.

3. Section 303.10 (Clearances) is being added since clearance requirements are currently addressed throughout the code for various equipment and appliances and it is rather confusing to what provisions apply due to redundant information provided throughout the code. Section 303.10 will indicate to the end user that where clearances are not referenced within the UMC, the clearances indicated in the manufacturer’s installation instructions should be used for both listed and unlisted equipment and appliances.

4. Section 303.10.1 is being added since clearance reduction requirements are currently addressed throughout the code and it is rather confusing to what provisions apply due to the redundant information provided throughout the code. Section 303.10.1 will indicate to the user reduction of clearance requirements that are needed for enforcement of the code that are based on NFPA 54. Furthermore, Table 802.7.3.4(2) is being relocated to Chapter 3 (General Requirements) since it provides clearance reduction requirements, for any equipment and appliances, which are required for the enforcement of the code. Table 506.7 is being deleted since the provisions are already addressed in Table 802.7.3.4(2).

5. Figure 904.2(1), Figure 904.2(2), and Figure 904.2(3) are being relocated to Chapter 3 (General Requirements) since it provides clearance reduction requirements, for all equipment and appliances, which are needed for the enforcement of the code. Figure 303.3 is being deleted since it the same as Figure 904.2(1). Furthermore, Figure 506.7 is being deleted since it is redundant to Figure 904.2(1). The notes in Figure 904.2(1) are being revised to correlate with NFPA 54-2012.

6. Section 506.7 and Section 506.7.5 are being revised to indicate the correct table for clearance reduction. The revisions should be done since Table 506.7 is being deleted due to its redundancy to Table 802.7.3.4(2), which is being relocated to Chapter 3 (see substantiation 4).

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Marguerite Carroll, UL, LLC

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

303.10.1 Clearance Reduction. Where permitted by the manufacturer, 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.

SUBSTANTIATION:
The text “where permitted by the manufacturer” is unnecessary language for listed equipment and appliances. Since clearances are determined as part of the listing, the proposed language could imply that the reduced clearance allowance is at the manufacturer’s discretion rather than in accordance with the product certification.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 16)

RECOMMENDATION:
Revise text as follows:

304.1 General. Equipment and appliances shall be accessible for inspection, service, repair, and replacement without removing permanent construction. Clearance shall be maintained to:
(1) Clean heating surfaces.
(2) Replace filters, blowers, motors, burners, controls, and vent connections.
(3) Lubricate moving parts.
(4) Adjust and clean burners, pilots, and the proper functioning of explosion vents, where provided. [NFPA 54:9.2.1]

304.1.1 Working Space. Unless otherwise specified, not less than 30 inches (762 mm) in depth, width, and height of working space shall be provided.

304.1.2 Platforms. Where the installation of an equipment or appliance is at an elevation of more than 30 inches (762 mm) above grade, a level platform shall be provided.

Exception: Unit heaters and room heaters shall be permitted to be installed with an 18 inches (457 mm) minimum depth working space. A platform shall not be required for unit heaters or room heaters. The operating instructions shall be attached to the appliance where they are capable of being read easily.

SUBSTANTIATION:
1. Section 304.1.1 is being revised to clarify to the end user that the provisions pertain to working spaces.
2. Section 304.1.2 is being added to provide platforms provisions for any installations of equipment or appliances at an elevation that can be hazardous. For example, it is not clear in the UMC that an installation on a slope roof will not only require the proper working space but a level platform as well. Due to the hazards of falling where on a sloped roof or high elevations, it is crucial that the UMC be clear on the requirements of platforms. Furthermore, the height requirement will be consistent with the building code for guard provisions.
3. The exception is being revised to remove language that contradicts Section 924.3. For informational purposes only, Section 924.3(2) is shown as follows: Room heaters other than those of the circulating type described in Section 924.3(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. [NFPA 54:10.23.4]. The current language in Section 304.1 increases the possibility that the user will fail to comply with the requirements of Section 924.3(2) and possibly create a fire hazard due to the heat being emitted by the room heater; Section 304.1 requires 18 inches (547 mm) and Section 924.3(2) requires 36 inches (914 mm).
4. The requirement for the operating instructions is being deleted since it is not an exception to the requirements of Section 304.1, and the provisions are already addressed in Section 303.2. For informational purposes only, Section 303.2 is being shown as follows: Except as otherwise provided in the code, the installation of appliances regulated by this code shall be in accordance with the conditions of listing. The appliance installer shall leave the manufacturer’s installation and operating instructions attached to the appliance. Clearances of listed appliances from combustible materials shall be as specified in the listing or on the rating plate.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed language is too broad, and it suggests that the equipment installed above a level ceiling requires a platform. The title “Working Space” should be removed since the language lacks dimensional specificity.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Erik Emblem, International Association of Sheet Metal Air Rail & Transportation Workers

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

304.1 General. Equipment and appliances shall be accessible for inspection, service, repair, and replacement without removing permanent construction. Clearance shall be maintained to:
(1) Clean heating surfaces.
(2) Replace filters, blowers, motors, burners, controls, and vent connections.
(3) Lubricate moving parts.
(4) Adjust and clean burners, pilots, and the proper functioning of explosion vents, where provided. [NFPA 54:9.2.1]

304.1.1 Working Space. Unless otherwise specified, not less than 30 inches (762 mm) in depth, width, and height of working space shall be provided.

304.1.2 Platforms. Where the installation of an equipment or appliance is at an elevation of more than 30 inches (762 mm) above grade, a level platform shall be provided.

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

SUBSTANTIATION:
The Technical Committee did not agree with the proposed language pertaining to platforms. However, they had no concerns pertaining to the revision to the exception. Therefore, the exception should be revised due to the following reasons:

1. The revision to the exception is necessary to remove language that contradicts Section 916.2.3. For informational purposes only, Section 916.2.3(2) is shown as follows: 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. [NFPA 54:10.23.4]. The current language in Section 304.1 increases the possibility that the user will fail to comply with the requirements of Section 924.3(2) and possibly create a fire hazard due to the heat being emitted by the room heater; Section 304.1 requires 18 inches (547 mm) and Section 916.2.3(2) requires 36 inches (914 mm).

2. The requirement for the operating instructions should be deleted since it is not an exception to the requirements of Section 304.1, and the provisions are already addressed in Section 303.1. For informational purposes only, Section 303.1 is being shown as follows: Except as otherwise provided in the code, the installation of appliances regulated by this code shall be in accordance with the conditions of listing. The appliance installer shall leave the manufacturer’s installation and operating instructions attached to the appliance. Clearances of listed appliances from combustible materials shall be as specified in the listing or on the rating plate.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
TAYLOR: The exception to Section 304.1.2 must also be deleted since Section 304.1.2 was deleted.
Item # 038  
UMC 2015 – (304.2.1.2):

SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 17)

RECOMMENDATION:
Revise text as follows:

304.2.1.2 Permanent Ladders. Permanent ladders required by Section 304.2.1.1 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 14 inches (356 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).

SUBSTANTIATION:
The proposed revision is consistent with the requirements of OSHA. OSHA indicates that: “Each step or rung of a fixed ladder must be capable of supporting a load of at least 300 pounds applied to the middle of the step or run”. All other revisions were done for clarity purposes and to bring the language in line with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Dennis G. Nolan, Nevada State Public Works Division

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

304.2.1.2 Permanent Ladders. Permanent ladders required by Section 304.2.1.1 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 (356 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).

SUBSTANTIATION:
The 2012 UMC [Section 304.2.1.2(4)] conflicts with OSHA CFR 1910.27(b)(ii). The UMC indicates that rung spacing shall not exceed 13 inches while OSHA indicates that it should be not more than 12 inches apart. When a fabricator builds the ladder with 13 inches of rung spacing, it meets the UMC but fails to meet OSHA requirements.

COMMITTEE ACTION: Accept the public comment as submitted
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Pennie L. Feehan
Pennie L. Feehan Consulting/Rep. Copper Development Association

RECOMMENDATION:
Revise text as follows:

307.1 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 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.

SUBSTANTIATION:
The marking section is restrictive and does not take into consideration nipples created from pipe.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Tim Ross, Ross Distributing, Inc.

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Such an exception is not necessary since Section 307.1 already indicates that “such markings shall be done by the manufacturer,” and that field markings are not permitted. Furthermore, such requirements do not correlate with the plumbing code.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The exception is necessary as the current marking requirements are too restrictive and does not take into consideration nipples created from pipe.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, but only as neces-
sary 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 # 042 for “marking” resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

**307.1 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 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.

**TCC COMMITTEE ACTION:** Reject

**TCC COMMITTEE STATEMENT:**
The TCC believes that the exception for Section 307.1 of the UMC should not be deleted, as it is necessary for clarity. Nipples created from cutting and threading of approved pipe are not required to have markings.

The revisions to Section 307.1 (Marking) of the UMC will correlate with Section 301.2.1 of the UPC, Section 302.1.1 of the USEHC, and Section 302.3 of the USPSHTC in regards to marking requirements for each length of piping.

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on Section 307.1 in regards to markings.
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 22)

RECOMMENDATION:
Add new text as follows:

308.3 Prohibited Location. Unless permitted elsewhere in this code, appliances shall not be installed in or in a space that communicates with the following:
(1) Bedrooms  
(2) Bathrooms  
(3) Toilet rooms  
(4) Storage rooms  
(5) Surgical rooms

SUBSTANTIATION:
1. Section 308.3 will reduce fire-threats to occupants by prohibiting the installation of appliances in locations where combustion can easily occur. Other potential threats to occupants are depleted oxygen levels, high levels of carbon monoxide, and nitrous oxides, etc. Spaces such as bedrooms, bathrooms, toilet rooms, and storage rooms are typically closed which can allow combustion gases to build-up to life-threatening levels. Spaces such as surgical rooms utilize combustible gases such as oxygen and flammable anesthetics.
2. The language “unless permitted elsewhere in this code” recognizes that there are provisions within the code where the installation of an appliance within such locations is permitted. For example, direct vent appliances have sealed combustion chambers and obtain all combustion air directly from the outdoors. A category I appliance is permitted to obtain combustion air from bedrooms or bathrooms in accordance with Section 902.2. Central heating furnaces and low-pressure boilers are permitted to be installed in a bedroom or bathroom under certain conditions in accordance with Section 904.1. Room heaters are permitted to be installed in such locations under certain conditions in accordance with Section 924.1.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed text was disapproved as it does not differentiate between fuel-burning appliances and other types of appliances that can be installed in bedrooms, bathrooms, toilet rooms, or surgical rooms.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Erik Emblem, International Association of Sheet Metal Air Rail & Transportation Workers

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

308.3 Prohibited Location. Unless permitted elsewhere in this code, fuel-burning appliances shall not be installed in or in a space that does not communicate with the following:
(1) Bedrooms  
(2) Bathrooms  
(3) Toilet rooms  
(4) Storage rooms  
(5) Surgical rooms
SUBSTANTIATION:
The reason why the Technical Committee rejected the proposal was because the language did not differentiate between fuel-burning appliances and other types of appliances. The proposed modification will address the Committee’s concern by indicating the provisions only apply to fuel-burning appliances. As indicated in the original substantiation, such spaces allow combustion gases such as oxygen, carbon monoxide, and nitrous oxide to build-up to life-threatening levels.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is too restrictive as it will prohibit certain installations such as water heaters or boilers installed in a basement.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 21)

RECOMMENDATION:
Revise text as follows:

911.8 308.3 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]

911.8.1 308.3.1 Repair Garages. Appliances installed in repair garages shall be installed in a detached building or room, separated from repair areas by walls, partitions, floors, or floor-ceiling assemblies that are constructed so as to prohibit the transmission of vapors and having a fire resistance rating of not less than 1 hour, and that have no openings in the wall separating the repair area within 8 feet (2438 mm) of the floor. Wall penetrations shall be firestopped. Air for combustion purposes shall be obtained from outside the building. The heating room shall not be used for the storage of combustible materials.

Exceptions:
(1) Overhead heaters where installed not less than 8 feet (2438 mm) above the floor shall be permitted.
(2) Heating appliances for vehicle repair areas where there is no dispensing or transferring of Class I or Class II flammable or combustible liquids or liquefied petroleum gas shall be installed in accordance with NFPA 30A. [NFPA 54:9.1.11.2]

SUBSTANTIATION:
Section 911.8 and Section 911.8.1 are being relocated to Chapter 3 (General Requirements) since they address requirements pertaining to the general installation of appliances in commercial garages and repair garages. The current location (Section 911.0) applies to duct furnaces only.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed text does not differentiate between fuel burning appliances and other appliances as to the reason for the new location within the code.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Dan Buuck, National Association of Home Builders (NAHB)

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

SUBSTANTIATION:
The Technical Committee’s reason for rejection was that “the proposed text does not differentiate between fuel burning appliances and other appliances.” However, the provisions apply to all appliances installed in commercial and repair garages. The current location (Section 911.8 and Section 911.8.1) applies to only duct furnace which does not correlate with NFPA 54. NFPA 54 indicates such provisions under their general appliance, equipment, and accessory installation section and not under the provisions for duct furnaces.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The Technical Committee believes that such provisions should be addressed in Chapter 9 (Installation of Specific Appliances) and not Chapter 3 (General Requirements) as it addresses specific installation requirements for appliances installed in commercial garages and repair garages.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
RECOMMENDATION:
Add new text as follows:

**308.3.1 Elevator Shaft.** Unless required for the functionality and safety of the elevator system, mechanical systems shall not be located in an elevator shaft.

**215.0 Mechanical System.** A system that is addressed and regulated in this code, and comprised of components, devices, equipment, and appliances.

SUBSTANTIATION:
1. Section 308.3.1 will prohibit the installation of mechanical systems in an elevator shaft. An elevator is relied upon for firefighting access; therefore, the space must be maintained free from contaminants that can come from mechanical systems, such as refrigerants, combustion products, heat transfer fluid, etc.
2. The term “mechanical system” is referenced in Section 308.3.1 without being defined. Furthermore, “mechanical system” is referenced in Sections 303.1, 307.1, 322.1, E 101.1, E 301.1, E 501.1, and E 605.1.2 without being defined. The proposed definition assists the end user in applying and enforcing this term.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

**215.0 Mechanical System.** A system that is addressed and regulated in this code, and comprised of components, devices, equipment, and appliances.

COMMITTEE STATEMENT:
The definition for “mechanical system” was deleted as it creates confusion and is subjective to interpretation. However, the committee acknowledges that a definition for “mechanical system” is necessary and that it should be written in a manner that is clear and concise.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Tim Ross, Ross Distributing, Inc.

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

SUBSTANTIATION:
The Technical Committee acknowledged that a definition for “mechanical system” is needed as it is being used in the code without being defined. The proposed language is consistent with industry practice and will provide a definition that is necessary to comply with the scope of the code.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The Technical Committee acknowledges that a definition for “mechanical system” is necessary. However, the definition was not written in a manner that is clear and concise.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
312.0 Condensate Wastes and Control.

312.1 Condensate Disposal. Condensate from air washers, air-cooling coils, fuel-burning 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 ¼ 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 either Section 312.3 or Section 312.4 for air-cooling coils or condensing fuel-burning appliances, respectively. Condensate or wastewater shall not drain over a public way.

312.2 Condensate Control. Where a cooling coil or cooling unit is located in an attic or furred space where damage is capable of resulting from condensate overflow, an additional watertight pan of corrosion-resistant metal shall be installed beneath the cooling coil or unit top to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow and a separate secondary drain shall be permitted to be provided in lieu of the secondary drain pan. The additional pan or the standing overflow shall be provided with a drain pipe, not less than ½ of an inch (20 mm) nominal pipe size, discharging at a point that is readily observed. This requirement is in addition to the requirements in Section 312.3 and Section 312.4.

312.3 Condensate Waste Sizing. Condensate waste pipes from air-cooling coils shall be sized in accordance with the equipment capacity as specified in Table 312.3.

<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>2</td>
</tr>
<tr>
<td>126 – 250</td>
<td>2</td>
</tr>
</tbody>
</table>

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 ¾ inch per foot (10.4 mm/m) or 1 percent slope, with the pipe running three-quarters full at the following pipe conditions:

(remaining text unchanged)
SUBSTANTIATION:
These revisions were done to correlate the UMC with the UPC. All other revisions were done in accordance with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates

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

312.2.1 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 or cooling coil, a watertight pan of corrosion-resistant materials shall be installed beneath the water heater with not less than $\frac{3}{4}$ of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than $1\frac{1}{2}$ inches (38 mm) in depth.

1105.7 Condensate. Condensate from air cooling coils shall be collected and drained in accordance with Section 312.0 to an approved location. Drains pans and coils shall be arranged to allow thorough drainage and access for cleaning. Where temperature drop below freezing heat tracing and insulation of condensate drains shall be installed.

SUBSTANTIATION:
1. The current language in Section 312.2 does not address drainage pan requirements for condensate disposal. Section 312.2.1 will provide the depth of the pan required as it is important for ensuring that enough space is provided for the drain connection fitting. Furthermore, such provisions were accepted by the UPC Technical Committee (Item # 161) and it should be correlated with the UMC.
2. Section 1105.7 should be revised as Section 312.0 provides general requirements for condensation control. Therefore, reference to Section 312.0 is necessary for ease of use of the code.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
This language is within the purview of the UPC.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
312.2.1 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 watertight pan of corrosion-resistant materials shall be installed beneath the water heater with not less than \( \frac{3}{4} \) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than \( 1\frac{1}{2} \) inches (38 mm) in depth.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The addition of Section 312.2.1 to the UMC will correlate with the actions taken by the UPC TC to “accept as submitted” Item # 161.

The substantiation provided by the UPC for accepting Item # 161 as submitted is as follows:

“1. The current language does not clearly address installations on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly which is the intent of this section of code, and has caused confusion within the industry in regards to the application and enforcement of this section.

2. The depth of the pan is important for ensuring that enough space is provided for the drain connection fitting generally located on the side of the pan.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UPC TC for action taken on Section 312.2.1 in regards to drainage pans.
SUBMITTER: Jeffrey Hutcher  
City of Oakland  

RECOMMENDATION:  
Add new text as follows:  

312.1.1 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.  

SUBSTANTIATION:  
Inspectors encounter multiple situations where condensate pumps are installed where they are not needed. In the cases where they are needed, they are not addressed by the code and are installed with 3/8 inch unlisted clear tubing to the exterior of the building; ignoring other sections which prohibit disposal over the public right of way. We have encountered over 100 ft of tubing run horizontally to the exterior or to open drains. Pumps sold as condensate are made to lift water, not to “throw” it multiple feet. This proposal gives the Authority Having Jurisdiction the authority to cite a specific code section which is currently lacking in the UMC.  

COMMITTEE ACTION: Reject  

COMMITTEE STATEMENT:  
The proposed text was disapproved as it is written in unenforceable terms, ambiguous and limits installations in seasonal homes.  

Note: Item # 052 failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.  

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.  
PUBLIC COMMENT (Assembly Action):  
SUBMITTER: Bob Adler, City of San Jose  

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

SUBSTANTIATION:  
The proposed language should be accepted based on the original substantiation.  

COMMITTEE ACTION: Accept the public comment as submitted  

TOTAL ELIGIBLE TO VOTE: 22  
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 24)

RECOMMENDATION:
Revise text as follows:

312.2 Condensate Control. Where a cooling coil or cooling unit is installed in an attic or furred in a space where damage is capable of resulting from condensate overflow, a drain line shall be provided and shall be drained in accordance with Section 312.1. 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 shall be installed beneath the cooling coil, unit, or appliance top to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow and a separate secondary drain shall be permitted to be provided in lieu of the secondary drain pan.

(3) An additional drain line at a level that is higher than the primary drain line connection of the drain pan.

This requirement is in addition to the requirements in Section 312.3 and Section 312.4.

SUBSTANTIATION:
1. The revisions to Section 312.2 will require an additional drain pipe, additional drain pan, or a level detecting device to protect the structure from condensate waste. The code currently does not provide the option for the installation of a water detecting device which is widely used in the industry for condensate protection.

2. Last sentence of Section 312.2 should be deleted as the provisions in Section 312.2 through Section 312.4 should all be adhered to in order to comply with the UMC.

COMMITTEE ACTION: Accept as Submitted

Note: Item # 053 failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Vickie Lovell, InterCode Inc./Rep. RectorSeal

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

312.2 Condensate Control. Where an equipment or appliance is installed in a space where damage is capable of resulting from condensate overflow, a drain line shall be provided and shall be drained in accordance with Section 312.1. 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.
An additional watertight pan of corrosion-resistant material with a water level detection device installed beneath the cooling coil, unit, or the appliance to catch the overflow condensate due to a clogged primary condensate drain and to shut off the equipment.

The additional pan or the additional drain line connection shall be provided with a drain pipe of not less than ¾ of an inch (20 mm) nominal pipe size, discharging at a point that is readily observed.

SUBSTANTIATION:
This modification to the proposal adds more detail in option 2, and adds a 4th option for controlling condensate. Item # 002 requires a drain pan for collecting condensate, but stops short of requiring the condensate to be able to drain from the pan, which could easily overflow and cause water damage if the equipment continues running. The new 4th option permits the use of a pan with a water detection device that would shut the equipment off, rather than draining of the pan. It is a nonmandatory option, and shut off may be the more appropriate and practical solution for some types of appliances.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20   NEGATIVE: 1   NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
ADLER: I vote to reject the TC acceptance of Public Comment 1 in favor of my Public Comment 2. I don't agree that a shut-off device that is used in lieu of a secondary drain is an equivalent substitution. I think that a secondary drain should be provided and if someone chooses to also use a shut-off, at least the drain is available.

Condensate drains are notorious for clogging because of debris from air-handling systems and the natural production of slime or bacteria growth in drain pans and pipes. Clogged drain pipes have historically caused serious damage to buildings and contents. Additionally, mold growth as a result of condensate that is not adequately drained has become a noticeable and serious health problem. A shut-off switch that turns off the AC unit when the primary drain line becomes clogged is not the equivalent of providing a secondary drain to a noticeable location. If someone wants to provide a shut-off switch to the drain pan, the water still needs an outlet from which it can be drained. Switches (a mechanical device) fail regularly and the contained water still needs an outlet. Therefore, a switch should be used in addition to, not in lieu of, the secondary drain line.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 266 (Public Comment 2) resulted in a conflict within this code in regards to “fuel burning appliances.” In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

310.0 Condensate Waste and Control.
310.1 Condensate Disposal. Condensate from air washers, air-cooling coils, fuel-burning 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 ¼ 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 either Section 310.3 or Section 310.4 for air-cooling coils or condensing fuel-burning appliances, respectively. Condensate or wastewater shall not drain over a public way.
310.4 Fuel-Burning Appliance Condensate Drains. Condensate drain lines from individual fuel-burning 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.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revisions made to the UMC in Section 310.1 (Condensate Disposal) and Section 310.4 (Fuel-Burning Appliance Condensate Drains) will correlate with actions taken by the UPC TC to “accept public comment as submitted” Item # 266 (Public Comment 2).

The substantiation provided by the UPC Item # 266 (Public Comment 2) is as follows: “These requirements are applicable to all condensing appliances and should not be restricted to only those that are fuel-burning. Text has been modified to eliminate reference to fuel-burning appliances to clarify that the requirements apply to all types of condensing appliances.”

PUBLIC COMMENT 2 (Assembly Action):
SUBMITTER: Bob Adler, City of San Jose

RECOMMENDATION: Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Condensate drains are notorious for clogging because of debris from air-handling systems and the natural production of slime or bacteria growth in drain pans and pipes. Clogged drain pipes have historically caused serious damage to buildings and contents. Additionally, mold growth as a result of condensate that is not adequately drained has become a noticeable and serious health problem. A shut-off switch that turns off the AC unit when the primary drain line becomes clogged is not the equivalent of providing a secondary drain to a noticeable location. If someone wants to provide a shut-off switch to the drain pan, the water still needs an outlet from which it can be drained. Switches (a mechanical device) fail regularly and the contained water still needs an outlet. Therefore, a switch should be used in addition to, not in lieu of, the secondary drain line.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1 as it provides acceptable methods for condensate control.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
ADLER: I vote to reject the TC acceptance of Public Comment 1 in favor of my Public Comment 2. I don’t agree that a shut-off device that is used in lieu of a secondary drain is an equivalent substitution. I think that a secondary drain should be provided and if someone chooses to also use a shut-off, at least the drain is available.

Condensate drains are notorious for clogging because of debris from air-handling systems and the natural production of slime or bacteria growth in drain pans and pipes. Clogged drain pipes have historically caused serious damage to buildings and contents. Additionally, mold growth as a result of condensate that is not adequately drained
has become a noticeable and serious health problem. A shut-off switch that turns off the AC unit when the primary drain line becomes clogged is not the equivalent of providing a secondary drain to a noticeable location. If someone wants to provide a shut-off switch to the drain pan, the water still needs an outlet from which it can be drained. Switches (a mechanical device) fail regularly and the contained water still needs an outlet. Therefore, a switch should be used in addition to, not in lieu of, the secondary drain line.
Item # 057

UMC 2015 – (312.3, 312.7):

SUBMITTER:  Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 26)

RECOMMENDATION:
Revise text as follows:

312.3 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 312.3. 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.

312.7 Plastic Fittings. Female PVC plastic screwed fittings shall be used with plastic male fittings and plastic male threads.

SUBSTANTIATION:
The revisions to Section 312.3 will guide the end user in selecting the correct material for condensate waste piping since the code is silent on such material requirements. Furthermore, in Section 312.7, the text “PVC” is being replaced with “plastic” since there are other plastic screwed fittings that can be used for condensate drains, as long as they meet the pressure and temperature ratings of the appliance or equipment.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER:  Piotr Zelasko, Radiant Professionals Alliance/ Rep. USEHC Working Group

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

312.3.1 Condensate Neutralization. Condensation associated with the combustion of gaseous fuels shall be required to have a replaceable or serviceable condensate neutralization unit to raise the pH of the discharged fluids to not less than 7.0. The neutralizer shall be readily accessible. The drain line between the condensing appliance and the pH neutralization unit shall not be combined. The piping prior to the condensate pH neutralization unit shall be compatible with the fluid being drained. Combination safety device relief waste and condensate waste shall not be permitted.

SUBSTANTIATION:
The critical neutralization of gas appliance condensate is not addressed in the UMC. As a result, untreated combustion condensate with a pH of less than 7.6 is being discharged into the sanitary sewer system causing failure of the metallic piping, and allowing the loss of sewage and entrance of gas vapors from the sanitary sewer. It is also known to negatively affect ISDS septic tank structures (concrete).

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed condensate neutralization provisions have not had public review as it introduces a new concept which was not included in a related proposal as published in the ROP. Furthermore, the provisions are too restrictive and further review is required.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2:
SUBMITTER: Andrew S. Jones, A Better Deal HVAC

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

312.3.1 Cleanouts. Condensate drain lines shall be configured or provided with a cleanout to permit the clearing of blockages and for maintenance without requiring the drain line to be cut.

SUBSTANTIATION:
Typically, when a condensate drain line is clogged, the technician cuts the drain line, and then collects as much of the waste water as possible. The technician then clears out the drain line and repairs it with a collar and PVC glue. It is possible with a drain cleanout device or by plumbing the drain line properly to avoid the necessity of cutting the drain line and repairing it. This saves time, money, and the problem of the waste water contaminating the residence. The proposed language was recently adopted into the 2015 IMC and 2015 IRC.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I disagree with the Committee action. There should not be a requirement on drain cleanouts, except where damage to the structure can occur, such as areas without a floor drain. This device would prevent cutting the drain line which could leak due to improper repair. The language in the proposal is also very vague and confusing. Is the commenter saying that the drain lines shall be configured with a cleanout to clear blockages or is the commenter saying drain lines shall be configured or provided with a cleanout to clear blockages? This can be interpreted differently than its intent.

CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (new Section 312.3.1 cleanouts) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”
312.6 Point of Discharge. Air-conditioning condensate waste pipes shall connect indirectly, except where permitted in Section 312.5, to the drainage system through an airgap or airbreak to properly 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.

SUBSTANTIATION:
The revisions to Section 312.6 will require condensate traps to comply with the manufacturer’s instructions. A properly functioning and designed condensate trap provides for discharge of water from the cooling coil drain pan, while the water seal (the water level maintained in the trap) prevents the flow of ambient air into or out of the air handler. Several problems result from improperly trapped systems, some of which can severely impact indoor air quality. Where a trap is improperly installed or designed, an incoming air stream may be introduced through the drain and the air flowing through the coil can possibly spray condensate into the fan intake, which can propel the moisture into other parts of the system; which can then be carried through the ducts and into the conditioned space possibly causing bacterial growth and transmission. Furthermore, improperly trapped systems can include the trap outlet is too short or the trap outlet is too tall, or other potential incorrect sizing. The manufacturer of the appliance typically provides trapping requirements that should be followed when sizing the condensate drainage trap.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Erik Emblem, International Association of Sheet Metal Air Rail & Transportation Workers

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

312.6 Point of Discharge. Air-conditioning condensate waste pipes shall connect indirectly, except where permitted in Section 312.5, to the drainage system through an airgap or airbreak 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.

SUBSTANTIATION:
The text “or as approved” should be removed as Section 302.2 always allows the AHJ to use an alternate material or method of construction equivalency.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The text “or as approved” should not be deleted as it is necessary for the enforcement of the section.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
314.2 Air Filters. Air filters shall be installed in a heating, cooling, or makeup air system. Such filters shall comply or labeled in accordance with UL 900, the standard, Air Filter Units, Test Performance of, that is referenced in Chapter 17, as Class I or II filters.

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.

503.3 Air Filters. Air filters shall be listed units. Liquid adhesive coatings used on filters shall have a flash point of more than 350°F (177°C) or higher, as determined in accordance with the fire code standards.

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, except as indicated below.

Exceptions:
1. (remaining text unchanged)
2. Air filters meeting the requirements of Section 314.2 and Section 503.3.
3. – (11) (remaining text unchanged)

SUBSTANTIATION:
1. Reference to UL 900 is being added to Section 314.2 to assist the end user in determining the appropriate standard that the air filters should be listed. UL 900 covers tests to determine combustibility and the amount of smoke generated for air filters units of both washable and throwaway types used for removal of dust and other airborne particles from circulated air. UL 900 is currently listed in Table 1701.0.
2. Section 503.3 is being deleted as UL 900 already indicates the flash point temperature requirements. The text “as determined in accordance with the fire code” is not necessary as the flash point is determined in accordance with ASTM D92 as indicated in UL 900. Furthermore, Section 602.2 is being revised since Section 503.3 is being deleted.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Marguerite Carroll, UL, LLC

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

314.2 Air Filters. Air filters shall be installed in a heating, cooling, or makeup air system. Media-type air filters shall be listed or labeled in accordance 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.

SUBSTANTIATION:
Text has been modified from original proposal to clarify that the scope of UL 900 pertains to media-type filters. Additional text clarifies that electrostatic and high efficiency particulate filters should comply with Section 936.0.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 064  Comment Seq # 017
UMC 2015 – (316.0 – 316.6, Table 316.5, 316.7):

SUBMITTER:  Dave Levanger
Chair, Technical Correlating Committee (TCC) (see TCC Report Item # 28)

RECOMMENDATION:
Revise text as follows:

316.0 Pipe, Tube Hangers, and Supports.

316.1 General. Piping, appliances, and tubing appurtenances shall be supported in accordance with this section code, the manufacturer’s installation instructions, and in accordance with the Authority Having Jurisdiction.

316.42 Strength Material. Hangers and anchors shall be of sufficient strength to support the weight of the pipe and its contents. Piping shall be isolated from incompatible materials.

316.23 Suspended Piping. Suspended piping shall be supported at intervals not to exceed those shown in Table 316.2 316.3.

316.34 Piping Support Alignment. Piping shall be supported in such a manner as to maintain its alignment and prevent sagging.

316.75 In Ground Underground Installation. Piping and tubing in the ground shall be laid on a firm bed for its entire length; except where other support is otherwise provided, it shall be approved by the Authority Having Jurisdiction in accordance with Section 306.0. Asbestos cement piping shall be provided with approved thrust blocking.

316.66 Hanger Rod Sizes. Hanger rod sizes shall be not smaller than those shown in Table 316.6 316.6.

TABLE 316.6 316.6
HANGER ROD SIZES

(portions of table not shown remain unchanged)

316.67 Gas Piping. Gas piping shall be supported by metal straps or hooks at intervals not to exceed those shown in Table 1311.2.5.1.

SUBSTANTIATION:
1. These proposed revisions will correlate the UMC with the Uniform Solar Energy Code (USEC). For informational purposes only, Section 307.1 through Section 307.5 of the USEC are shown as follows:

307.0 Hangers and Supports.

307.1 Components of Solar Energy System. Components of a solar energy system shall be supported in accordance with this code, the manufacturer’s installation instructions, and in accordance with the Authority Having Jurisdiction.

307.2 Material. Hangers and anchors shall be of sufficient strength to support the weight of the pipe and its contents. Piping shall be isolated from incompatible materials. Pipe hangers and supports shall be of sufficient strength to withstand all static and dynamic loading conditions in accordance with its intended use. Pipe hangers and supports with direct contact with piping shall be of approved materials that are compatible with the piping and will not cause galvanization.

307.3 Suspended Piping. Suspended piping shall be supported at intervals not to exceed those shown in Table 307.3.

307.4 Alignment. Piping shall be supported in such a manner as to maintain its alignment and prevent sagging.

307.5 Underground Installation. 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.

2. The TCC believes that Section 316.2 (Material) should not be correlated with the USEC as it will make the provisions for materials too restrictive for all types of occupancies.

COMMITTEE ACTION: Accept as Submitted
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates

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

316.0 Hangers and Supports.
316.1 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.
316.2 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.
316.3 Suspended Piping. Suspended piping or tubing shall be supported at intervals not to exceed those shown in Table 316.3.
316.4 Alignment. Piping or tubing shall be supported in such a manner as to maintain its alignment and prevent sagging.
316.5 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 306.0.

SUBSTANTIATION:
Tubing is commonly used in hydronics systems. Therefore, the provisions for hangers and supports should be modified to also apply to tubing installations. Furthermore, the modification will correlate with similar change submitted to the 2015 Uniform Solar Energy & Hydronics Code (USEHC), which was accepted by the USEHC Technical Committee.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
**Item # 065**

UMC 2015 – (Table 316.2):

**SUBMITTER:** Larry Gill  
IPEX USA LLC

**RECOMMENDATION:**  
Add new text as follows:

### TABLE 316.2  
HANGER AND SUPPORTS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-RT</td>
<td>Metal and plastic insert and metal compression</td>
<td>32 inches</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**SUBSTANTIATION:**  
PE-RT is already in the UMC and the required support spacing needs to be added. The proposed spacing matches PEX.

**COMMITTEE ACTION:** Accept as Amended by the TC  
Amend proposal as follows:

### TABLE 316.2  
HANGER AND SUPPORTS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
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<tbody>
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<td>PE-RT</td>
<td>Metal and plastic insert and metal compression</td>
<td>32 inches</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1 inch and smaller, 32 inches; 1/4 inches and larger, 4 feet</th>
</tr>
</thead>
</table>

**COMMITTEE STATEMENT:**  
Table 316.2 was modified based on previous action taken on the UPC in regards to hangers and supports for PE-RT joints.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 051 for “Hangers and Supports” resulted in a conflict within this code. In order to correlate language the following **Technical Correlating Committee proposed action to the UMC is shown as follows:**
TABLE 316.2
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>Copper &amp; Copper Alloys Tube and Pipe</td>
<td>Soldered, or Brazed, Threaded, or Mechanical</td>
<td>1½ inches and smaller, 6 feet; 2 inches and larger, 10 feet</td>
<td>Each floor, not to exceed 10 feet³</td>
</tr>
<tr>
<td>Steel and Brass Pipe for Water or DWV</td>
<td>Threaded or Welded</td>
<td>½ inch and smaller, 10 feet; 1 inch and larger, 12 feet</td>
<td>Every other floor, not to exceed 25 feet⁴</td>
</tr>
<tr>
<td>Steel, Brass, and Tinned Copper Pipe for Gas</td>
<td>Threaded or Welded</td>
<td>½ inch, 6 feet; ½ inch and 1 inch, 8 feet; 1¼ inches and larger, 10 feet</td>
<td>½ inch, 6 feet; ¼ inch and 1 inch, 8 feet; 1¼ inches every floor level</td>
</tr>
<tr>
<td>Copper</td>
<td>Mechanical</td>
<td>In accordance with standards acceptable to the Authority Having Jurisdiction</td>
<td>In accordance with standards acceptable to the Authority Having Jurisdiction</td>
</tr>
<tr>
<td>Steel and Brass</td>
<td>Mechanical</td>
<td>In accordance with standards acceptable to the Authority Having Jurisdiction</td>
<td>In accordance with standards acceptable to the Authority Having Jurisdiction</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**TCC COMMITTEE ACTION:** Accept as Submitted

**TCC COMMITTEE STATEMENT:**
The revisions to Table 316.2 (Hanger and Supports) of the UMC will correlate with the actions taken by the UPC TC to “accept as submit” Item # 051.

The reasons provided by the UPC TC for “accepting as submitted” Item # 051 are as follows:
1. Brass and bronze are copper alloys.
2. This proposal eliminates outdated language and provides the appropriate terminology and correct information to the end user.

The following proposed action moves forward as approved by the TCC and supersedes any recommendation from the UMC TC.

**A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**

**PUBLIC COMMENT:**

**SUBMITTER:** Pennie L. Feehan, Pennie L. Feehan Consulting/Rep. Copper Development Association

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

**1109.2 Joints.** Iron or steel pipe joints shall be of approved threaded, flange, or welded types. Exposed threads shall be tinned or coated with an approved corrosion inhibitor. Copper or brass copper alloy pipe joints of iron pipe size shall be of approved threaded, flange, or brazed types. Copper tubing joints and connections shall be approved flared, lapped, swaged, or brazed joints. Piping and tubing shall be installed so as to prevent vibration and strains at joints and connections.

**205.0 Copper Alloy.** A homogenous mixture of two or more metals in which copper is the primary component, such as brass and bronze.

**SUBSTANTIATION:**
In Section 1109.2, the term “brass” should be modified to “copper alloy” as it is the terminology being used in the industry. Furthermore, The definition for “copper alloy” should be added to maintain uniformity with NFPA 54.
COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

TABLE 316.2
HANGER AND SUPPORTS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-RT</td>
<td>Insert and Compression</td>
<td>1-inch and smaller, 32 inches; 1/2-inch and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

(portion of table not shown remain unchanged)

COMMITTEE STATEMENT:
The modification to Table 316.2 will correlate with similar modifications made to the UPC in regards to hanger and supports for PE-RT piping and tubing.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 18 NEGATIVE: 3 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CUDAHY: While PPFA had to oppose the increased spacing of PE-RT due to the content of the ASTM standard for PE-RT at the TC hearing, we understand there is now an ASTM work item to correct the limitation, as PE-RT and PEX are very similar, and may even be made on identical equipment, we expect the modification to the ASTM standard to be accepted and the spacing restored.

The text shown below was submitted to a similar change in the UPC (Item #059) as it also limited the support spacing for PE-RT:

Plastic Pipe and Fittings Association – May 16, 2014

Technical reasons for changing the IAPMO UPC Technical Committee Vote on Item #59 (and UMC Item #065) with Respect to 48-inch (4 foot) Horizontal Support Spacing for PE-RT above 1-inch in diameter is as follows:

During the TC meeting there was discussion about the proper support spacing for PE-RT pipe above 1 inch in diameter. A problem arose because the ASTM Standard for PE-RT (in an appendix) requires 32 inch support spacing for all sizes of the product. Calculations for the support spacing allow the 48-inch support spacing for pipe above 1 inch in diameter. The formula for calculating the allowable support spacing for piping FULL OF WATER is a standard beam equation:

\[ f = \frac{wL}{EI}L^3/185 \]

Where:
- \( f \) = The allowable deflection or sag between supports
- \( W \) = Total weight of tube and water between supports
- \( E \) = Modulus of Elasticity of the tube material
- \( I \) = Moment of Inertia of the cross-section of the tube
- \( L \) = Distance between supports

Furthermore, I’m attaching a table that would give you values for the variables in the equation above, if you want to do the math. The “L” distance between supports is 48 inches. The green cells in the table represent those PE-RT
sizes where 48-inch supports can be used. These are essentially the same values as are used for PEX. The allowable deflection is 0.15 inch, which is the deflection of 1/2” PE-RT at 32” support spacing.

In addition, a Project # has been granted by the ASTM F17.26 chairman and a ballot issued to change section X3.1.5 of Standard F2769 (PE-RT) to show the new support spacing requirements.

Since PE-RT can be shown to allow support spacing of 48 inches above 1 inch diameter and the relevant ASTM standard will be changed accordingly, we ask your support in voting to overturn the TC action on this Item # 065. Doing so will mean that the support spacing table as originally proposed by the IAPMO Code Review Task Group would go into the 2015 code.

We’re asking that you vote “Negative with Comment” and the comment should relate to the engineering calculation that proves the support spacing in the originally submitted table (see attached).
<table>
<thead>
<tr>
<th>Name</th>
<th>Quantity</th>
<th>Unit</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>100</td>
<td>Unit</td>
<td>$50.00</td>
<td>$5000.00</td>
</tr>
<tr>
<td>Item 2</td>
<td>50</td>
<td>Unit</td>
<td>$100.00</td>
<td>$5000.00</td>
</tr>
<tr>
<td>Item 3</td>
<td>200</td>
<td>Unit</td>
<td>$75.00</td>
<td>$15000.00</td>
</tr>
<tr>
<td>Item 4</td>
<td>150</td>
<td>Unit</td>
<td>$60.00</td>
<td>$9000.00</td>
</tr>
<tr>
<td>Item 5</td>
<td>120</td>
<td>Unit</td>
<td>$72.00</td>
<td>$8640.00</td>
</tr>
<tr>
<td>Item 6</td>
<td>80</td>
<td>Unit</td>
<td>$90.00</td>
<td>$7200.00</td>
</tr>
<tr>
<td>Item 7</td>
<td>30</td>
<td>Unit</td>
<td>$120.00</td>
<td>$3600.00</td>
</tr>
<tr>
<td>Item 8</td>
<td>40</td>
<td>Unit</td>
<td>$150.00</td>
<td>$6000.00</td>
</tr>
<tr>
<td>Item 9</td>
<td>25</td>
<td>Unit</td>
<td>$200.00</td>
<td>$5000.00</td>
</tr>
</tbody>
</table>

**Total:** $59000.00
SCARANO: In accordance with the ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing, which is referenced in Table 1201.3.1 of the 2012 UMC, Section X3.1.5 Horizontal Support Spacing in ASTM F876 - The maximum recommended spacing between horizontal supports is 32 in. (800 mm) for diameter up to 1 ¼ in. There is no mention of increased support spacing of sizes above 1 ¼ inches in the standard. In accordance with the ASTM F2769 Standard Specification of Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems, which is referenced in Table 1201.3.1 of the 2012 UMC, Section X3.1.5 Horizontal Support Spacing in ASTM F2769 - The maximum recommended spacing between horizontal supports is 32 inches (800 mm) for all sizes. Both the PEX and PERT standards are SDR 9 products. SDR is the Standard Dimension Ratio which means they have the same wall thickness and outside diameters. Therefore, the PERT support spacing should also be included in Table 316.2 in the code with the same support spacing requirements as PEX.

Based on the above comparisons of support spacing in the standards, code change Item # 065 submitted by Larry Gill of IPEX and the UMC Committee's original action, this item should be accepted as originally submitted.

OWENS: I agree with the comments provided by Michael Cudahy and Tony Scarano.

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The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 065 and UPC Item # 059 resulted in a conflict within this code in regards to hangers and supports for PE-RT piping and tubing. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

**TABLE 316.2**

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>TYPES OF JOINTS</th>
<th>HORIZONTAL</th>
<th>VERTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-RT</td>
<td>Insert and Compression</td>
<td>1 inch and smaller, 32 inches; 1 ¼ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

**TCC COMMITTEE ACTION:** Accept as Submitted

**TCC COMMITTEE STATEMENT:**

The revision to Table 316.2 of the UMC will correlate with the actions taken by the UPC TC to not accept a similar revision made to Table 313.1 of the UPC.

The Committee statement provided by the UMC TC for accepting as amended Item # 065 is as follows:

“The modification to Table 316.2 will correlate with similar modifications made to the UPC in regards to hanger and supports for PE-RT piping and tubing.”

However, Public Comment (Item # 059) of the UPC failed to achieved 2/3 votes during balloting. Therefore, the reason statement provided by the UMC TC is no longer valid as the similar modifications failed to achieved 2/3 votes.

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken Table 316.2 in regards to hangers and supports for PE-RT piping and tubing.
319.0 Protection of Piping, Materials, and Structures.
319.1 General. Piping 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 passing through concrete floors on the ground shall be sealed.
319.2 Fire-Resistant Construction. Piping 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.
319.3 Steel Nail Plates. Plastic piping, copper piping, 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 1\(\frac{1}{2}\) inches (38 mm) beyond the outside diameter of the pipe or tubing.
Exception: See Section 1311.3.3.
320.0 319.4 Sleeves for Piping. 320.1 General. 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.
320.2 319.4.1 Bearing Building Loads. Piping through concrete or masonry walls shall not be subject to a load from building construction.
320.3 319.4.2 Sealing Exterior Walls. In exterior walls, annular space between sleeves and pipes shall be sealed and made watertight, as approved by the Authority Having Jurisdiction. A penetration through fire-resistive construction shall be in accordance with the building code and applicable standards referenced in Table 1701.0 Section 319.2.
320.4 319.4.3 Through Firewalls. A pipe sleeve through a firewall shall have the space around the pipe completely sealed with an approved fire-resistive material in accordance with other codes.
321.0 Cutting Structure 319.5 Structural Members. 321.1 General. 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.
322.0 319.6 Rodent Proofing. 322.1 General. (remaining text unchanged)

(renumber remaining sections)

SUBSTANTIATION:
1. Sections 319.2 and 319.3 are being added to correlate with the UPC to address the minimum requirements for penetration of piping and ducts through fire-resistant construction. The intent of Section 319.3 is to minimize the possibility of mechanical piping, refrigerant piping, ducts or other components in concealed locations from being damaged from the use of nails, screws, or other fasteners. The shield plate will protect the piping where the nails, screws or other fasteners miss the framing member. The exception to Section 319.3 recognizes that provisions for steel plates for fuel gas tubing are indicated in Section 1311.3.3.
2. Sections 320.2, 320.3, 320.4, 321.0, 321.1, and 322.0 pertaining to the protection of piping, materials, and structures are being restructured and revised to correlate with the UPC for like sections.
3. Section 1201.3.8.6 is not necessary as sleeves are already addressed in Section 319.4, and therefore redundant.

COMMITTEE ACTION: Accept as Submitted
The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 066 for “Steel Nail Plates” and UPC Item # 051 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

319.3 Steel Nail Plates. Plastic piping, copper or copper alloy piping, 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 1 1/2 inches (38 mm) beyond the outside diameter of the pipe or tubing. Exception: See Section 1311.3.3.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revision to Section 319.3 (Steel Nail Plates) of the UMC will correlate with the actions taken by the UPC TC to “accept as submit” Item # 051.

The reason provided by the UPC TC for “accepting as submitted” Item # 051 is as follows: Brass and bronze are copper alloys. This proposal eliminates outdated language and provides the appropriate terminology and correct information to the end user.

The following proposed action moves forward as approved by the TCC and supersedes any recommendation from the UMC TC for action taken on Section 319.3 in regards to the protection of piping with steel nail plates.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates
RECOMMENDATION: Request to accept the code change proposal as modified by this public comment.

319.0 Protection of Piping, Tubing, Materials, and Structures.
319.1 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.

319.2 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.

319.3 Corrosion, Erosion, and Mechanical Damage. Piping or tubing subject to corrosion, erosion, or mechanical damage shall be protected in an approved manner.

319.4 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.

319.25 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.

319.36 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 1311.3.3.

**319.4.7 Sleeves.** (remaining text unchanged)

**319.4.17.1 Building Loads.** Piping or tubing through concrete or masonry walls shall not be subject to a load from building construction.

**319.4.27.2 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-resistant construction shall be in accordance with Section 319.2.

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

**319.6.2 Structural Members.** (remaining text unchanged)

**319.6.10 Rodentproofing.** Mechanical system shall be constructed in such a manner that rats cannot enter as to restrict rodents or vermin from entering a building by following the duct work from the outside into the building.

**319.7.11 Ductwork or Pipes - Metal Collars.** (remaining text unchanged)

**SUBSTANTIATION:**

Sections 319.2, 319.3, and 319.4 are being added as they are applicable to hydronic system installations. All other modifications were done to correlate with the 2015 USEHC and the 2015 UPC.

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  
- **AFFIRMATIVE:** 20  
- **NEGATIVE:** 1  
- **NOT RETURNED:** 1 Garza

**EXPLANATION OF NEGATIVE:**

**CABOT:** The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (Section 319.2, Section 319.3, and Section 319.4) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review. ANSI defines a substantive changes as follows:

Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 003 (Public Comment 1) resulted in a conflict within this code in regards to “construction documents.” In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

**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 plans and specifications shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said plans and specifications 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.

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 plans, diagrams, computations, 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 Plans and Specifications. Plans and specifications shall be submitted in one two 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 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 plans, calculations, or other data where the Authority Having Jurisdiction finds that the nature of the work applied for is such that reviewing of plans 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 plans and specifications 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.

104.3.3 Information on Plans and Specifications. Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall indicate the location, nature, and extent of the work proposed and show in detail that it is in accordance with the provisions of this code and relevant laws, ordinances, rules, and regulations.

The Authority Having Jurisdiction shall have the option to accept plans and specifications electronically, in lieu of on cloth or paper, in whatever format it shall require.

104.4 Permit Issuance. The application, plans, specifications, 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 plans and specifications “APPROVED.” Such approved plans and specifications 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 plans and specifications 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 plans and specifications, 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 plans and specifications, construction documents for such work, and provided further that such suspension or abandonment has not exceeded 1 year.

104.4.6 Retention of Plans. One set of approved plans, specifications, 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 plans, specifications, 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.

D 11.2 Metallic Gas Piping. 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 in accordance with the provisions of 49 CFR 192. [NFPA 501A:4.3.7.2.1, 4.3.7.2.2]

205.0

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.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:

1. The revisions to Sections 103.3, 104.3, 104.3.1, 104.3.2, 104.4, 104.4.1, 104.4.2, 104.4.3, 104.4.6, and D 11.2 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 003 (Public Comment 1) in regards to “construction documents.”

The committee statement provided by the UPC TC for revising “plans and specifications” to “construction documents” in Item # 003 (Public Comment 1) is as follows:

“This proposed code change updates the administrative requirements by using the proper terminology which is “construction documents,” not “plans and specifications.” The other change is to require a minimum of two sets of documents to be submitted. This is necessary so that the inspection department can have a set for permanent records, while one set is used for field inspections. The requirement is also consistent with the building code which requires a minimum of two sets of plans.

The final change relates to the requirement for construction documents to be submitted by a licensed architect or engineer. There is no exception in any state laws that allow an administrative authority to allow a non-licensed individual to prepare construction documents. This corrects the requirement by stipulating that a licensed engineer or architect must prepare construction documents. In addition, construction documents are required to be drawn to scale. This is also required in state law for licensed architects and engineers.

With the additionally language in Section 103.2.1, Section 103.2.2 becomes redundant. Hence, it is proposed for deletion. Additionally, Section 103.2.2 is archaic in its requirement for plans to be drawn on paper or cloth. Cloth hasn’t been used in the architectural and engineering profession for more than 40 years. Most plans are prepared on the computer using some form of a computer aided design. Certain building departments are allowing plans to be submitted electronically. By striking Section 103.2.2, the administrative authority can accept plans and construction documents either electronically or by hard copy.”
2. The new definition for “construction documents” of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 003 (Public Comment 1).

The term “construction documents” is referenced in Section 104.4.1, Section 402.1.1, Section E 503.3.1(13), Section E 503.6.3.1, Section E 503.6.5.1, Section E 503.6.5.2, Section E 503.6.5.3, Section E 802.1(7), and Section E 803.2 of the UMC without being defined. The definition assists the end user in applying and enforcing this term.

The Committee statement provided by the UPC TC for accepting public comment Item # 003 (Public Comment 1) as amended is as follows: “The definition for “construction documents” is being modified as plans and specifications are commonly used as part of construction documents.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 007 and USEHC Item # 008 resulted in a conflict within this code in regards to “registered design professional.” In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

**302.3.1 Permit Application.** The registered designer professional engineer shall indicate on the design documents that the mechanical system, or parts thereof, is an alternative engineered design so that it is noted on the construction permit application. The permit and permanent permit records shall indicate that an alternative engineered design was part of the approved installation.

**302.3.2 Technical Data.** The registered designer professional engineer shall submit sufficient technical data to substantiate the proposed alternative engineered design and to prove that the performance meets the intent of this code.

**302.3.3 Design Documents.** The registered designer professional engineer shall provide two complete sets of signed and sealed design documents for the alternative engineered design for submittal to the Authority Having Jurisdiction. The design documents shall include floor plans of the work. Where appropriate, the design documents shall indicate location, sizing, and loading of appurtenances, equipment, appliances, and devices.

**302.3.5 Design Review.** The Authority Having Jurisdiction shall have the authority to require testing of the alternative engineered design in accordance with Section 302.2.1, including the authority to require an independent review of the design documents by a registered designer professional engineer selected by the Authority Having Jurisdiction and at the expense of the applicant.

**TCC COMMITTEE ACTION:** Accept as Submitted

**TCC COMMITTEE STATEMENT:**
Sections 302.3.1, 302.3.2, 302.3.3, and 302.3.5 of the UMC are being revised to correlate with the actions taken by the UPC TC to “accept as submitted” Item # 007. Furthermore, it will correlate with the actions taken by the USEHC TC to “accept as submitted” Item # 008.

The substantiation provided by the UPC Item # 007 to accept as submitted is as follows:
“This proposed change is to add a definition and correlate the industry recognized term “registered design professional” with the related terms currently used in the Uniform Plumbing Code (UPC). This same proposal is being submitted for all standards developed by IAPMO. The term “registered design professional” is the accepted term for an architect, engineer, or other professional who is licensed and certified by a state to practice their respective design profession. This is also the term as used and defined in the construction and safety codes adopted by almost all state and local jurisdictions throughout the U.S.”
The definition in the International Building Code (IBC), the International Residential Code (IRC), and the California Building Code (CBC) is: **REGISTERED DESIGN PROFESSIONAL** An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

The definition as used in the codes and standards developed by NFPA is: **REGISTERED DESIGN PROFESSIONAL** An individual who is registered or licensed to practice his/her respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

As shown in the proposed change (above), the terms “architect or engineer”, “registered engineer”, “registered professional engineer”, “licensed architect, or engineer”, “engineer of record” “engineer or architect licensed by the state to practice as such”, “engineer licensed by the state to practice as such”, “a person registered, licensed, or deemed competent by the Authority Having Jurisdiction to perform…“, “a person registered or licensed to perform plumbing design work”, “an engineer or architect licensed by the state to practice as such”, and “licensed design professional” are used interchangeably to refer to the same professional certification. The term “registered design professional” is currently used in UPC Sections 911.1 and E 505.1.1.

The change will replace the many different terms used throughout the UPC to describe a registered design professional with the industry accepted term, and by adding the definition will eliminate the need to define the term in many separate sections of the code.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC.
RECOMMENDATION:
Revise text as follows:

402.2.1 Location and Size of Openings. Spaces, or portions of spaces, to be naturally ventilated spaces shall be permanently open by way of operable wall openings directly to the outdoors, the openable area of which is a minimum of 4 percent of the net occupiable floor area. Where the openings are covered with louvers or otherwise obstructed, openable area shall be based on the net free unobstructed area through the opening. Where interior spaces, 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 less than 25 square feet (2.3 m²). [ASHRAE 62.1:6.4.2]

(remaining text unchanged)

403.2 Zone Calculations. Ventilation 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 design outdoor airflow required in the breathing zone 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 in square feet.
- $P_z =$ zone population: The largest number of people in expected to occupy the ventilation 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 listed in Table 402.1.

(remaining text unchanged)

403.2.2 Zone Air Distribution Effectiveness. The zone air distribution effectiveness ($E_z$) shall be not greater than the default value determined using in accordance with Table 403.2.2. [ASHRAE 62.1:6.2.2.2]

| TABLE 403.2.2 |
| ZONE AIR DISTRIBUTION EFFECTIVENESS$^{1,2,3,4,5}$ |
| ASHRAE 62.1: TABLE 6-2 |

Notes:

1. “Cool air” is air cooler than space temperature.
2. “Warm air” is air warmer than space temperature.
3. “Ceiling” includes any point above the breathing zone.
4. “Floor” includes any point below the breathing zone.
5. As an alternative to using the above values, determine $E_z$ shall be permitted to be regarded as equal to air change effectiveness determined in accordance with ASHRAE Standard 129 for all air distribution configurations except unidirectional flow.

(portions of table not shown remain unchanged)
403.2.3 Zone Outdoor Airflow. The design 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]

\[
V_{oz} = \frac{V_{bz}}{E_z} \quad \text{(Equation 403.2.3)}
\]

403.3 Single-Zone Systems. Where For ventilation system where one or more air handler supplies 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]

\[
V_{ot} = V_{oz} \quad \text{(Equation 403.3)}
\]

403.4 One Hundred Percent Outdoor Air Systems. Where For ventilation system where one or more air handler supplies 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]

\[
V_{ot} = \sum_{\text{all zones}} V_{oz} \quad \text{(Equation 403.4)}
\]

403.5 Multiple-Zone Recirculating Systems. Where For ventilation systems where one or more air handlers supply a mixture of outdoor air and recirculated return 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]

\[
Z_{pz} = \frac{V_{oz}}{V_{pz}} \quad \text{(Equation 403.5.1)}
\]

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 return air. [ASHRAE 62.1:6.2.5.1]

403.5.2 System Ventilation Efficiency. The system ventilation efficiency \( E_v \) shall be determined in accordance with Table 403.5.2 or Section 404.0. [ASHRAE 62.1:6.2.5.2]

<table>
<thead>
<tr>
<th>MAX ( Z_{pz} )</th>
<th>( E_v )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 0.15 )</td>
<td>1.0</td>
</tr>
<tr>
<td>( \leq 0.25 )</td>
<td>0.9</td>
</tr>
<tr>
<td>( \leq 0.35 )</td>
<td>0.8</td>
</tr>
<tr>
<td>( \leq 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 \( Z_{pz} \)” refers to the largest value of \( Z_{pz} \) calculated in accordance with Equation 403.5.1, among all the ventilation zones served by the system.
2 Interpolating between table values is permitted. For values of Max \( Z_{pz} \) 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 all 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 will yield more practical results.
403.5.3 Uncorrected Outdoor Air Intake. The design 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]

\[
V_{ou} = D \sum \text{all zones} \left( R_p \cdot P_z \right) + \sum \text{all zones} \left( R_a \cdot A_z \right) \quad \text{[Equation 403.5.3(1)]}
\]

The occupant diversity ratio \( D \) shall be permitted to be used determined in accordance with Equation 403.5.3(2) to account for variations in occupancy population within the ventilation zones served by the system. The occupancy diversity is determined in accordance with Equation 403.5.3(2):

\[
D = \frac{P_s}{\sum \text{all zones} P_z} \quad \text{[Equation 403.5.3(2)]}
\]

Where the system population \( P_s \) is the total population in the area served by the system.

**Exception:** Alternative methods shall be permitted to be used to account for population occupant diversity where calculating \( V_{ou} \) shall be permitted, provided that the resulting \( V_{ou} \) value is not less than that determined in accordance with Equation 403.5.3(1). [ASHRAE 62.1:6.2.5.3.1]

**SUBSTANTIATION:**
Sections 402.2.1, 403.2, 403.2.1, 403.2.2, 403.2.3, 403.4, 403.5, 403.5.1, 403.5.2, 403.5.3, Table 403.2.2, and Table 403.5.2 are being revised to correlate with ASHRAE 62.1-2010.

**COMMITTEE ACTION:** Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

**PUBLIC COMMENT:**
**SUBMITTER:** Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

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

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, 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 Section 402.2.3. 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]

402.2.1.1 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 as 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]

402.2.13 Location and Size of Openings. (remaining text unchanged)

(renumber remaining text)
TABLE 402.1
MINIMUM VENTILATION RATES IN BREATHING ZONE 1, 2, 4
[ASHRAE 62.1: TABLE 6-1.2.2.1]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY</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$^4$ (people/1000 ft$^2$)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISCELLANEOUS SPACES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezer and refrigerated spaces (&lt;50°F)$^5$</td>
<td>10</td>
<td>$_______$</td>
<td>$______$</td>
<td>2</td>
</tr>
<tr>
<td>SPORTS AND ENTERTAINMENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gym, sports arena (play area)$^6$</td>
<td>20</td>
<td>0.18</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Gym, stadium (play area)</td>
<td>$______$</td>
<td>0.30</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Sports arena (play area)$^*$</td>
<td>$______$</td>
<td>0.30</td>
<td>$______$</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes:
(1) - (4) (remaining text unchanged)

ITEM-SPECIFIC NOTES FOR TABLE 402.1

a. For high school and college libraries, use values shown for Public Assembly Spaces – Libraries.
b. Rate is capable of not being 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. “Deck area” refers to the area surrounding the pool that would be expected to be 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”).
d. Rate does not include special exhaust for stage effects, (e.g., dry ice vapors, 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.

(remaining text unchanged)

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 and/or Section 404.0, or both.

(remaining text unchanged)

TABLE 403.2.2
ZONE AIR DISTRIBUTION EFFECTIVENESS$^1, 2, 3, 4, 5$
[ASHRAE 62.1: TABLE 6-26.2.2.2]

<table>
<thead>
<tr>
<th>AIR DISTRIBUTION CONFIGURATION</th>
<th>$E_z$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling supply of cool air$_c$</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceiling supply of warm air and floor return$_f$</td>
<td>1.0</td>
</tr>
<tr>
<td>Ceiling supply of warm air at least 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</td>
</tr>
<tr>
<td>Floor supply of cool air and ceiling return$_c$, provided that the vertical throw is more than 450 fpm supply jet reaches at a height of at least 4.5 feet or more above the floor.</td>
<td>1.0</td>
</tr>
<tr>
<td>Floor supply of cool air and ceiling return$_c$, 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$_f$</td>
<td>1.0</td>
</tr>
<tr>
<td>Floor supply of warm air and ceiling return$_f$</td>
<td>0.7</td>
</tr>
<tr>
<td>Makeup supply drawn in on the opposite side of the room from the exhaust or return, or both.</td>
<td>0.8</td>
</tr>
<tr>
<td>Makeup supply drawn in near to the exhaust or 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 Standard 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 6-36.2.5.2]

(portion of table not shown remain unchanged)

Notes:
1. (1) \( E_v \)
2. (remaining text unchanged)
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 \( V_{out} \) 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.

### 403.6 Design for Varying Operating Conditions
Ventilation systems shall be designed to be capable of providing not less than the minimum required 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, 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 shall be determined in accordance with Equation 403.2.1 and design value of the zone population \( P_z \), cubic foot per minute (cfm).

Acceptable design adjustments based on this optional provision shall be in accordance with 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 \( V_{out} \) calculated using Equation 403.3, Equation 403.4, or Equation 403.5.4. [ASHRAE 62.1:6.2.6.2]
TABLE 403.7
MINIMUM EXHAUST RATES
[ASHRAE 62.1: TABLE 6-46.5]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY[4]</th>
<th>EXHAUST RATE (cfm/unit)</th>
<th>EXHAUST RATE (cfm/ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint spray booths</td>
<td>-</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Parking garages[5]</td>
<td>-</td>
<td>0.75</td>
<td>2</td>
</tr>
<tr>
<td>Refrigerating machinery rooms[6]</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Residential kitchens[7]</td>
<td>50/100</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Toilets-private[5]</td>
<td>25/50</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Toilets-public[5]</td>
<td>50/70</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

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 is not required for open parking garages as defined in accordance with the building code.
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 theatres, schools, and sports facilities. Otherwise the lower rate shall be permitted to be used.
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 rate is not required for enclosed parking garages having a floor area of 1000 square feet (92.9 m²) or less and used for the storage of five or less motorized vehicles.

SUBSTANTIATION:
Section 402.2, Table 403.5.2, Section 403.6, Section 403.6.1 and Table 403.7 are being modified to correlate with ASHRAE 62.1-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). Furthermore, Section 402.2.1 (Floor Area to Be Ventilated) through Section 402.2.1.4 (Ceiling Height) should be added as they are required to enforce Section 402.2.3 (Location and Size of Openings) in regards to the vertical distance from the space to a natural ventilation opening. The distance requirement was removed from the UMC to correlate with ASHRAE 62.1-2010 during the 2012 cycle. As a result, the AHJ has no direction on how to enforce the location of the distance to natural ventilation opening as required in Section 402.2.3 (Location and Size of Openings). Section 402.2.1 (Floor Area to Be Ventilated) through Section 402.2.1.4 (Ceiling Height) will correlate with ASHRAE 62.1-2013.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 30)

RECOMMENDATION:
Add new text as follows:

403.7.1 Alternative Exhaust Ventilation for Enclosed Parking Garages. Mechanical ventilation systems for enclosed parking garages 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.

403.7.1.1 Minimum Exhaust Rate. Ventilation systems shall be capable of providing 14,000 cfm (6607.3 L/s) of exhaust air for each operating vehicle. The number of operating vehicles shall be determined based on 2.5 percent of the parking spaces and not less than one vehicle.

403.7.1.2 Automatic Carbon Monoxide Sensing Devices. Automatic carbon monoxide sensing devices shall be permitted to be employed to modulate the ventilation system to maintain a maximum average concentration of carbon monoxide of 50 parts per million during an eight-hour period, with a concentration of not more than 200 parts per million for a period not exceeding one hour. Automatic carbon monoxide sensing devices installed to modulated parking garage ventilation systems shall be approved.

SUBSTANTIATION:
Section 403.7.1 through Section 403.7.1.2 will allow an alternate design for ventilation systems for enclosed public parking garages. The alternating or modulating is intended to protect the occupants from excess levels of carbon monoxide and as a means of conserving energy. The provisions will correlate with language used in the California Mechanical Code.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

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

403.7.1 Alternative Exhaust Ventilation for 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.

403.7.1.1 Minimum Exhaust Rate. Ventilation systems shall be capable of providing 14,000 cfm (6607.3 L/s) of exhaust air for each operating vehicle. The number of operating vehicles shall be determined based on 2.5 percent of the parking spaces and not less than one vehicle.

403.7.1.2 Automatic Carbon Monoxide Sensing Devices. Approved. Automatic carbon monoxide sensing devices shall be permitted to be employed to modulate the ventilation system to maintain not exceed a maximum average concentration of carbon monoxide of 50 parts per million during an eight-hour period, with a concentration of not more than 200 parts per million 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.
SUBSTANTIATION:
Section 403.7.1 through Section 403.7.1.2 should be modified to correlate with the 2013 California Mechanical Code. For informational purposes only, Section 403.9 of the California Mechanical Code is shown as follows:

403.9 Exhaust Ventilation for Enclosed Parking Garages.
Exhaust airflow for enclosed parking garages shall be provided in accordance with the requirements in Table 403.7 and this section. Exhaust makeup air shall be permitted to be any combination of outdoor air or transfer air. Exhaust systems shall operate continuously.

Exceptions:
(1) Mechanical ventilation systems used for enclosed parking garages shall be permitted to operate intermittently where the system is arranged to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices.

(2) Automatic carbon monoxide sensing devices may be employed to modulate the ventilation system to not exceed a maximum average concentration of carbon monoxide of 50 parts per million during any eight-hour period, with a maximum concentration not greater than 200 parts per million for a period not exceeding one hour. Automatic carbon monoxide sensing devices employed to modulate parking garage ventilation systems shall be approved pursuant to the requirements in Section 302.1.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

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

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY(a)</th>
<th>EXHAUST RATE (cfm/unit)</th>
<th>EXHAUST RATE (cfm/(ft^2))</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Garages(3,7)</td>
<td>-</td>
<td>0.75</td>
<td>2</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

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 is not required for open parking garages as defined in accordance with the building code.
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 theatres, schools, and sports facilities. Otherwise the lower rate shall be used.
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 used. Otherwise the higher rate shall be used.

6 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.

2 Exhaust rate is not required for enclosed parking garages having a floor area of 1000 square feet (92.9 m²) or less and used for the storage of five or less motorized vehicles.

4 For continuous system operation, the lower rates shall be permitted. Otherwise the higher rate shall be used.

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 m²) or less and used for the storage of 5 or less vehicles.

(renumber remaining sections)

SUBSTANTIATION: In Table 403.7, note 7 currently does not correlate with ASHRAE 62.1-2013. Therefore, note 7 should be relocated to its own Section.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
403.9 Air Classification and Recirculation. Air shall be classified, and the recirculation or transfer shall be limited in accordance with Section 403.9.1 through Section 403.9.3. [ASHRAE 62.1:5.16] Recirculated air shall not be taken from prohibited locations in accordance with Section 314.3.

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 be permitted to be recirculated or transferred to Class 1 spaces. Where an energy recover device is used, Class 2 air that is recirculated from leakage, carryover, or transfer from the exhaust side of the energy recovery device is permitted and shall not exceed 10 percent of the outdoor air. [ASHRAE 62.1:5.16.3.2]

403.9.3 Class 3 Air. Recirculation of Class 3 air within the same space of origin shall be permitted. Class 3 air shall not be recirculated or transferred to other spaces. Where an energy recover device is used, Class 3 that is recirculated from leakage, carryover, or transfer from the exhaust side of the energy recovery device is permitted and shall not exceed 5 percent of the outdoor air. [ASHRAE 62.1:5.16.3.3]

403.9.4 Class 4 Air. Class 4 air shall not be recirculated or transferred. [ASHRAE 62.1:5.16.3.4]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY</th>
<th>PEOPLE OUTDOOR Air Rate $R_p$ (cfm/person)</th>
<th>AREA OUTDOOR Air Rate $R_A$ (cfm/ft²)</th>
<th>DEFAULT OCCUPANT Density (people/1000 ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORRECTIONAL FACILITIES</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>
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<tr>
<td>Cell</td>
<td>5</td>
<td>0.12</td>
<td>25</td>
<td>2</td>
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<tr>
<td>Day room</td>
<td>5</td>
<td>0.06</td>
<td>30</td>
<td>1</td>
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<tr>
<td>Guard stations</td>
<td>5</td>
<td>0.06</td>
<td>15</td>
<td>1</td>
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<tr>
<td>EDUCATIONAL FACILITIES</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>
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</tr>
<tr>
<td>Classrooms (age 9 plus)</td>
<td>10</td>
<td>0.12</td>
<td>35</td>
<td>1</td>
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<tr>
<td>Computer lab</td>
<td>10</td>
<td>0.12</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Day care (through age 4)</td>
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<td>0.18</td>
<td>25</td>
<td>1</td>
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<tr>
<td>Day care sickroom</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Lecture classroom</td>
<td>7.5</td>
<td>0.06</td>
<td>65</td>
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<tr>
<td>Lecture hall (fixed seats)</td>
<td>7.5</td>
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<td>150</td>
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<tr>
<td>Media center*</td>
<td>10</td>
<td>0.12</td>
<td>25</td>
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<tr>
<td>Music/theater/dance</td>
<td>10</td>
<td>0.06</td>
<td>35</td>
<td>1</td>
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<tr>
<td>Multi-use assembly</td>
<td>7.5</td>
<td>0.06</td>
<td>100</td>
<td>1</td>
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<tr>
<td>Science laboratories*</td>
<td>10</td>
<td>0.18</td>
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<td>University/college laboratories</td>
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<td>Wood/metal shop</td>
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<td>OCCUPANCY CATEGORY*</td>
<td>PEOPLE OUTDOOR</td>
<td>AREA OUTDOOR</td>
<td>DEFAULT OCCUPANT</td>
<td>AIR CLASS</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-------------------</td>
<td>-----------</td>
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<tr>
<td></td>
<td>Air Rate RP</td>
<td>Air Rate RA</td>
<td>Density*</td>
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<tr>
<td></td>
<td>(cfm/person)</td>
<td>(cfm/ft²)</td>
<td>(people/1000 ft²)</td>
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<td><strong>FOOD AND BEVERAGE SERVICE</strong></td>
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<td></td>
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<tr>
<td>Bars, cocktail lounges</td>
<td>7.5</td>
<td>0.18</td>
<td>100</td>
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<tr>
<td>Cafeteria/fast food dining</td>
<td>7.5</td>
<td>0.18</td>
<td>100</td>
<td>2</td>
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<tr>
<td>Kitchen (cooking)</td>
<td>7.5</td>
<td>0.12</td>
<td>20</td>
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<td>Restaurant dining rooms</td>
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<td>0.18</td>
<td>70</td>
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<td><strong>GENERAL</strong></td>
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<tr>
<td>Break rooms</td>
<td>5</td>
<td>0.06</td>
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<td>Coffee stations</td>
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<td>0.06</td>
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<td>Conference/meeting</td>
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<td>50</td>
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<td>Corridors</td>
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<td>1</td>
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<tr>
<td>Occupiable storage rooms for liquids or gelsb</td>
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<td>0.12</td>
<td>2</td>
<td>2</td>
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<tr>
<td><strong>HOTELS, MOTELS, RESORTS, DORMITORIES</strong></td>
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<td>Barracks sleeping areas</td>
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<td>Bedroom/living room</td>
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<td>Laundry rooms, central</td>
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<td>Laundry rooms within dwelling units</td>
<td>5</td>
<td>0.12</td>
<td>10</td>
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<tr>
<td>Lobbies/pre-function</td>
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<td>Multipurpose assembly</td>
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<td><strong>OFFICE BUILDINGS</strong></td>
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<td>Breakrooms</td>
<td>5</td>
<td>0.12</td>
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<tr>
<td>Occupiable storage rooms for dry materials</td>
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<td>0.06</td>
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<tr>
<td>Office space</td>
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<td>0.06</td>
<td>5</td>
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</tr>
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<td>Reception areas</td>
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<td>0.06</td>
<td>30</td>
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</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>
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<tr>
<td>Bank or bank lobbies</td>
<td>7.5</td>
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<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>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>
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<tr>
<td>Photo studios</td>
<td>5</td>
<td>0.12</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Shipping/receivingb</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>7</td>
<td>2</td>
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<tr>
<td>Telephone closets</td>
<td>–</td>
<td>0.00</td>
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<td>1</td>
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<tr>
<td>Transportation waiting</td>
<td>7.5</td>
<td>0.06</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Warehousesb</td>
<td>10</td>
<td>0.06</td>
<td>–</td>
<td>2</td>
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<tr>
<td><strong>PUBLIC ASSEMBLY SPACES</strong></td>
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<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>Libraries</td>
<td>5</td>
<td>0.12</td>
<td>10</td>
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</tr>
<tr>
<td>Lobbies</td>
<td>5</td>
<td>0.06</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Museums (children’s)</td>
<td>7.5</td>
<td>0.12</td>
<td>40</td>
<td>1</td>
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<tr>
<td>Museums/galleries</td>
<td>7.5</td>
<td>0.06</td>
<td>40</td>
<td>1</td>
</tr>
</tbody>
</table>
### For SI units: 1 cubic foot per minute = 0.0283 m³/min, 1 square foot = 0.0929 m²

### Notes:

1. This table applies to no-smoking areas. Rates for smoking-permitted spaces must be determined using other methods.
2. Volumetric airflow rates are based on an 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. 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 values shown for Public Spaces – Library.
- **b** Rate is capable of not being 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 be required to remove moisture.
- **d** Rate does not include special exhaust for stage effects, (e.g., dry ice vapors, smoke).
- **e** No class of air has been established for this occupancy category. Where combustion equipment is intended to be used on the playing surface, 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 space outside of that dwelling.
TABLE 403.7
MINIMUM EXHAUST RATES
[ASHRAE 62.1: TABLE 6-4]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY</th>
<th>EXHAUST RATE (cfm/unit)</th>
<th>EXHAUST RATE (cfm/ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arenas¹</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</td>
<td>–</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>Locker/dressing rooms</td>
<td>–</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>Parking garages¹,²</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>Residential – kitchens³</td>
<td>50/100</td>
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</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</td>
<td>25/50</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Toilets – public⁴</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 The rates do not include exhaust from vehicles or equipment with internal combustion engines. 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 is not required for open parking garages as defined in accordance with the building code.
⁴ Rate is per water closet, or 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 used.
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 used. Otherwise the higher rate shall be used.
⁶ 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.
⁷ Exhaust rate is not required for enclosed parking garages having a floor area of 1000 square feet (92.9 m²) or less and used for the storage of five or less motorized vehicles.
⁸ For continuous system operation, the lower rates shall be permitted. Otherwise the higher rate shall be used.

203.0

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]

SUBSTANTIATION:
1. Recirculating air to another occupancy or area of dissimilar use from which it is taken could subject the occupants to contaminants or odors that are not inherent to the specific occupancy or space. Such contaminants or odors could be harmful to the occupants or be objectionable. Section 403.9 through Section 403.9.4 will indicate to the end user limits for the recirculation of air; the limits will assist the end user to what “air class” can and cannot be recirculated or transfer to other spaces. The “air class” column added for each occupancy have been identified for each category in Table 402.1 and Table 403.7 so the end user can readily determine what air can be recirculated and to where it can be recirculated to. All of the proposed revisions are consistent with the requirements in ASHRAE 62.1-2010 in regards to recirculation of air.

2. In Section 403.9, the reference to Section 314.3 recognizes that there are additional restrictions to where return air cannot be obtained from, regardless of the air class.

3. The terms “Air, Class 1”, “Air, Class 2”, “Air, Class 3”, and “Air, Class 4” are referenced in Section 403.9 through Section 403.9.4 without being defined. The proposed definitions assist the end user in applying and enforcing this term.

4. All other changes were done to correlate the UMC with ASHRAE 62.1-2010.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

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

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 permitted to be recirculated or transferred to Class 1 spaces. Where using energy recovery device is used, Class 2 air that is recirculated or transferred 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 same space of origin shall be permitted. Class 3 air shall not be recirculated or transferred to other spaces. Where using energy recovery device is used, Class 3 air that is recirculated or transferred 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 other spaces or be recirculated within the space of origin. [ASHRAE 62.1:5.16.3.4]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY</th>
<th>EXHAUST RATE (cfm/unit)</th>
<th>EXHAUST RATE (cfm/ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilets-private</td>
<td>25/50</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Toilets-public</td>
<td>50/70</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)
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 is not required for open parking garages as defined in accordance with the building code.
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 theatres, schools, and sports facilities. Otherwise the lower rate shall be used.
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 used. Otherwise the higher rate shall be used.
6 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.
7 Exhaust rate is not required for enclosed parking garages having a floor area of 1000 square feet (92.9 m²) or less and used for the storage of five or less motorized vehicles.
8 For continuous system operation, the lower rates shall be permitted. Otherwise the higher rate shall be used.
9 Exhaust air that has been cleaned in accordance with the criteria of Class 1 shall be permitted to be recirculated.

SUBSTANTIATION:
Section 403.9.2, Section 403.9.4, Section 403.9.5, and Table 403.7 are being modified to correlate with ASHRAE 62.1-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 075  
UMC 2015 – (404.2.2):

SUBMITTER:  Dave Levanger  
Chair, Technical Correlating Committee (TCC) (see TCC Report Items # 154)

RECOMMENDATION:
Revise text as follows:

404.2.2 General Case Secondary Recirculation Systems. Equation 404.2.2 shall be used for systems that provide all or part of their ventilation by recirculating air from other zones. For “secondary-recirculation” systems where the supply air or a portion thereof to a ventilation zone is recirculated air from other zones, without being directly mixing it with outdoor air, the zone ventilation efficiency ($E_v$) shall be determined in accordance with Equation 404.2.2(1). Examples of secondary-recirculation systems include (e.g., dual-fan dual duct, fan-powered mixing box, and transfer fans for conference rooms). [ASHRAE 62.1:A1.2.2]

$$E_v = \frac{(F_a + X_s \cdot F_b - Z_{pz} \cdot E \cdot F_c)}{F_a}$$  \[Equation 404.2.2(1)\]

The system air fractions $F_a$, $F_b$, and $F_c$ shall be determined in accordance with Equation 404.2.2(2), Equation 404.2.2(3), and Equation 404.2.2(4). The Zone primary air fraction ($E_p$) shall be determined in accordance with Equation 404.2.2(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]

$$F_a = E_p + (1 - E_p) \cdot E_r$$  \[Equation 404.2.2(2)\]

$$F_b = E_p$$  \[Equation 404.2.2(3)\]

$$F_c = 1 - (1 - E_z) \cdot (1 - E_r) \cdot (1 - E_p)$$  \[Equation 404.2.2(4)\]

$$E_p = \frac{V_{pz}}{V_{dz}}$$  \[Equation 404.2.2(5)\]

Where:

$E_p$ - Primary air fraction to the zone: $E_p = \frac{V_{pz}}{V_{dz}}$ ($E_p = 1.0$ for single duct and single zone systems). 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.

$F_a$ - Supply air fraction: The fraction of supply air to the ventilation zone from sources or air outside the zone: $F_a = \frac{V_{pz}}{V_{dz}}$.

$F_b$ - Mixed air fraction: The fraction of supply air to the ventilation zone from fully mixed primary air: $F_b = \frac{V_{pz}}{V_{dz}}$.

$F_c$ - Outdoor air fraction: The fraction of outdoor air to the ventilation zone: $F_c = 1 - (1 - E_z) \cdot (1 - E_r) \cdot (1 - E_p)$.

$V_{dz}$ - Zone Discharge Airflow: The expected discharge (supply) airflow to the zone that includes primary airflow and locally secondary recirculated airflow, cubic feet per minute (L/s).

$V_{pz}$ - System Primary Airflow: The total primary airflow supplied to all zones served by the system from the air handling unit at which the outdoor air intake is located: $V_{pz} = \sum V_{pz}$.

$V_{dz}$ - 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: $X_s = \frac{V_{sz}}{V_{pz}}$.

$Z_{pz}$ - Primary Outdoor Air Fraction: The outdoor air fraction required in the primary air supplied to the ventilation zone prior to the introduction of a secondary recirculation airflow: $Z_{pz} = \frac{V_{oz}}{V_{pz}}$. [ASHRAE 62.1: Appendix A4]
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. $E_v$ is equal to the lowest calculated value of the zone ventilation efficiency $E_{vz}$ as shown below. 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: Appendix A1.3]

\[ E_v = \min (E_{vz}) \quad \text{(Equation 404.1)} \]

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.

\[ X_s = \frac{V_{ou}}{V_{ps}} \quad \text{(Equation 404.2)} \]

The uncorrected outdoor air intake ($V_{ou}$) shall be determined in accordance with Section 403.5.3, and the system primary airflow ($V_{ps}$) is found at the condition analyzed. [ASHRAE 62.1:A1.1]

404.23 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. The zone ventilation efficiency shall be determined in accordance with Section 404.23.1 or Section 404.23.2. [ASHRAE 62.1:Appendix A1.2]

404.23.1 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 404.23.1(1). Examples of single supply systems include constant-volume reheat, single-duct VAV, single-fan dual-duct, and multizone systems.

\[ E_{vz} = 1 + X_s - Z_{pz} \quad \text{[Equation 404.23.1(1)]} \]

The average outdoor air fraction for the system ($X_s$) for the system shall be determined in accordance with Equation 404.2.1(2) and the primary outdoor air fraction for the zone ($Z_{pz}$) for the zone shall be determined in accordance with Section 403.5.1. [ASHRAE 62.1:A1.2.1]

\[ X_s = \frac{V_{ou}}{V_{ps}} \quad \text{[Equation 404.2.1(2)]} \]

The uncorrected outdoor air intake ($V_{ou}$) shall be determined in accordance with Section 403.5.3, and the system primary airflow ($V_{ps}$) is found at the condition analyzed. [ASHRAE 62.1:A1.1]

404.23.2 Secondary-Recirculation Systems. For “secondary-recirculation” systems where the supply air or a portion thereof to a ventilation zone is recirculated air from other zones, without being directly mixed with outdoor air, the zone ventilation efficiency ($E_{vz}$) shall be determined in accordance with Equation 404.23.2(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.
(remaining text unchanged)

**SUBSTANTIATION:**
Section 404.1 through Section 404.3 are being modified to correlate with ASHRAE 62.1-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  
AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 39)

RECOMMENDATION:
Revise text as follows:

504.2 Independent Exhaust Systems. Single or combined mechanical exhaust systems shall be independent of other exhaust systems.

504.3 Domestic Range Vents. Ducts used for domestic kitchen range ventilation shall be of metal and shall have smooth interior surfaces. Ducts for domestic range hoods shall serve cooking appliances.

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 grease-tight duct.
(4) The PVC duct shall terminate protrude not more than 1 inch (25.4 mm) above grade outside the building and shall be equipped with a back-draft damper.

(COMMITTEE ACTION: Reject)

COMMITTEE STATEMENT:
Exception 2 is not technically correct as 6 inches is the required diameter for a PVC coupling. Furthermore, the 1 inch requirement in Exception 4 should be more specific and indicate a transition point and not a termination point.

SUBSTANTIATION:
1. Section 504.2 (Independent Exhaust Systems) will prohibit an environmental air duct system from being combined with other environmental air duct systems serving a different purpose. Independent ducts will minimize the potential spread of contaminants, hazardous exhaust, fire, or smoke to other parts of a building.
2. The text removed from Section 504.3 (Domestic Range Vents) was done to remove redundant language since the proposed new Section 504.2 (Independent Exhaust Systems) will require independent duct systems.
3. Text from Exception 2 was deleted since duct systems for domestic ranges can be smaller than 6 inches in diameter.
4. The text “vent” and “ventilation” are being deleted from Section 504.2 (Domestic Range Vents) since it may cause confusion between ducts used for ventilation versus ducts used for exhaust. Chapter 5 deals with exhaust systems and not ventilation systems; ducts for ventilation systems are addressed in Chapter 6.
5. Redundant language was deleted from Exception 4 since Section 504.1 already indicates that a backdraft damper is required for environmental air ducts, which includes ducts used for domestic ranges. Furthermore, the text “protrude not more than 1 inch (25.4 mm)” and the text “PVC” was added to Exception 4 for consistency with language used in Exception 2 and Exception 3 of Section 504.2 (Domestic Range Vents).
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:

SUBMITTER: Erik Emblem, International Association of Sheet Metal Air Rail & Transportation Workers

RECOMMENDATION:

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

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 ranges 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 (150 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 grease-tight duct.
4. The PVC duct shall terminate protrude not more than 1 inch (25.4mm) above grade outside the building and shall be equipped with a back-draft damper.

SUBSTANTIATION:

The Technical Committee had concerns only with the revisions proposed to Exception 2 and Exception 4. However, nothing was said in regards to Section 504.2 (Independent Exhaust Systems) which will prohibit an environmental air duct system from being combined with other environmental air duct systems serving a different purpose. Independent ducts will minimize the potential spread of contaminants, hazardous exhaust, fire, or smoke to other parts of a building. The text removed from Section 504.3 (Domestic Range) was done to remove redundant language since the proposed new Section 504.2 (Independent Exhaust Systems) will require independent ducts systems.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

TAYLOR: The language in Section 504.2 is very confusing. I believe the intent is that environmental exhaust should not be combined with non-environmental exhaust (e.g. grease, product conveying like garage exhaust). There is certainly nothing wrong with combining toilet exhaust with janitor's exhaust or even residential kitchen exhaust, which is very common in high rise residential. The following language should be considered: “504.2 Independent Exhaust Systems. Environmental mechanical exhaust systems shall be independent of non-environmental exhaust systems.”
Item # 093

UMC 2015 – (504.5):

SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 45)

RECOMMENDATION:
Add new text as follows:

504.5 Discharge. Environmental exhaust ducts shall not discharge onto a public walkway and shall discharge to a location where the exhaust air is not capable of being drawn back into a space by a ventilating system.

(renumber remaining sections)

SUBSTANTIATION:
The proposed language will prevent the exhaust airstream from being discharged in a manner that could result in a health hazard.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed language is incomplete, unenforceable, and does not contain dimensions for the discharge location.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Erik Emblem, International Association of Sheet Metal Air Rail & Transportation Workers

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

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.

504.5 Discharge. Environmental exhaust ducts shall not discharge onto a public walkway and shall discharge to a location where the exhaust air is not capable of being drawn back into a space by a ventilating system.

SUBSTANTIATION:
Section 504.5 has been revised to address the Technical Committee’s concerns. The 10 feet distance has been added to Section 502.2.1 for ease of use of the code. The 10 feet is consistent with the exhaust provisions found in the UMC and the UPC for vent terminals, and with current industry practice.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

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. 504.5 Discharge. Environmental exhaust ducts shall not discharge onto a public walkway.
COMMITTEE STATEMENT:
Section 502.2.1 should be combined with Section 504.5 for ease of use of the code as they both deal with exhaust termination requirements.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The 10 foot separation is already in Section 314.3 but that section allows the intake if the exhaust outlet is 3 feet above the intake, so there is a conflict. Furthermore, the discharge to a public walkway is too vague: how high above the walkway? A distance (e.g. 10 feet) needs to be added or the entire sentence should be deleted. Really, what is the health hazard of blowing environmental exhaust onto a sidewalk? Note that, technically, economizer relief air is “environmental exhaust” and it has the same air quality as inside spaces so there is zero added health risk.
TABLE 505.2

MINIMUM CONVEYING DUCT DESIGN VELOCITIES

<table>
<thead>
<tr>
<th>TYPE OF PRODUCTS</th>
<th>NATURE OF CONTAMINANTS</th>
<th>EXAMPLES</th>
<th>DESIGN VELOCITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vapors, gases, smoke, fumes</td>
<td>Vapors, gases, and smoke</td>
<td>Any</td>
<td></td>
</tr>
<tr>
<td>Fum</td>
<td>Welding</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Fine light dusts, such as cotton, lint, and wood flour (100 mesh and under)</td>
<td>Cotton lint, wood flour, litho powder</td>
<td>2000-2500</td>
<td></td>
</tr>
<tr>
<td>Dry dusts and powders, such as iron rubber, molding power, soap dust</td>
<td>Fine rubber dust, molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings</td>
<td>2500-3000</td>
<td></td>
</tr>
<tr>
<td>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>
<td></td>
</tr>
<tr>
<td>Heavy dusts, such as metal turnings, lead 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>
<td></td>
</tr>
<tr>
<td>Heavy or moist dusts and chips, such as lead dust with chips, sticky buffing lint, quick-lime dust</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>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1 foot per minute = 0.005 m/s

* The velocity for aluminum and magnesium powder shall be not less than 4000 feet per minute (20 m/s).

506.7 Duct Clearances. Ductwork and system components handling combustible material and operating at less than 140°F (60°C) shall have a clearance of not less than 18 inches (457 mm) from combustible construction or a combustible material. [NFPA 91:4.6.2]

Exceptions:
(1) Where the ductwork system is operating at less than 140°F (60°C) and is equipped with an approved automatic extinguishing system designed for the specific hazard, the clearance shall be permitted to be reduced to 6 inches (152 mm) from combustible materials and ½ of an inch (12.7 mm) from combustible construction. [NFPA 91:4.6.2.1]

(2) Where the combustible material and construction is protected by the use of materials or products listed for protection purposes or in accordance with Table 506.7.

506.7.1 Spacers and Ties. Spacers and ties for protection materials shall be of noncombustible material and shall not be used directly behind the duct installed on the duct side of the protection system. [NFPA 91:4.6.4.2]

506.7.7 Reduced Clearance. Where clearance is reduced by using an airspace air gap between the combustible surface wall and the wall protector and the selected means of protection, air circulation shall be provided by one of the following sections methods in accordance with Section 506.7.7.1 through Section 506.7.7.3. [NFPA 91:4.6.4.7]
506.7.7.1 Wall Protector. Air circulation shall be permitted to be provided by leaving edges of the wall protector system open with not less than a 1 inch (25.4 mm) air gap. [NFPA 91:4.6.4.7.1]

506.7.7.2 Single Flat Wall. Where the wall protector 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 the top and bottom edges open to circulation by maintaining the 1 inch (25.4 mm) air gap. [NFPA 91:4.6.4.7.2]
2. Leaving the top and both side edges open to circulation by maintaining the 1 inch (25.4 mm) air gap. [NFPA 91:4.6.4.7.2]

506.7.7.3 Wall Protectors that Cover Two Walls. Wall protector 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 91:4.6.4.7.3]

SUBSTANTIATION:
1. Table 505.2, and Sections 506.7, 506.7.1, 506.7.7, 506.7.7.1, 506.7.7.2, and 506.7.7.3 are being revised to correlate with NFPA 91-2010.
2. All other revisions were done to comply with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Jeff Hutcher, City of Oakland

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

TABLE 505.2
MINIMUM DUCT DESIGN VELOCITIES*
[NFPA 91: TABLE A.4.1.5]

(portions of table not shown remain unchanged)

* Systems that are handling combustible particulate solids shall be accordance with NFPA 654.

SUBSTANTIATION:
(Attachments for Item # 099 are included in the substantiation CD presented to the TC)

The table as proposed could lead to fire or dust explosions; the extraction of the table was taken without regard to the considerate scope of the NFPA 91 Annex. Adoption of this comment would correlate with the provisions of the Annex of NFPA 91 from where the table originated. See Annex (Section A7.2) of NFPA 91.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 52)

RECOMMENDATION:
Revise text as follows:

506.5 Supports. Supports shall be of noncombustible materials and the spacing shall not exceed 12 feet (3658 mm) for 8 inch (203 mm) ducts nor 20 feet (6096 mm) for larger ducts, unless justified by the design.

506.5.1 Loads. Duct supports shall be designed to carry the weight of the duct half filled with material. [NFPA 91:4.5.1]
Where sprinkler protection is provided in the duct or cleaning of duct will be performed, the hanger’s design shall include the weight of the duct half filled with water or with the material being conveyed, whichever has the higher density expected liquid accumulation. Duct supports shall be designed to prevent placing loads shall not be placed on connecting equipment. [NFPA 91:4.5.1-4.5.3]

Exception: Where approved drainage is provided, the weight of the water shall not require consideration.

506.5.2 Corrosion. Hangers and supports exposed to corrosive atmospheres shall be Type 316 SS or equivalent corrosion resistant. [NFPA 91:4.5.4]

SUBSTANTIATION:
1. Section 506.5 is being revised to include the requirements for noncombustible supports. Combustible supports can cause the duct system to fail in the event of a fire. Furthermore, combustible supports can possibly cause a fire hazard since most product conveying ducts can convey air exceeding 250°F (121°C). The language “unless justified by the design” is being removed since the Authority Having Jurisdiction always has the option to accept alternate materials when calculations and documentations indicate that the design is equal or better than the required provisions.
2. All other revisions are being done to correlate with NFPA 91-2010.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Peter B. Kelly, Massachusetts Sheet Metal Board

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

506.5 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.

SUBSTANTIATION:
This proposal should be revised as the support spacing that is indicated is not consistent with industry standards. All ducts should have a set spacing distance and should not be dependent on the overall length of the duct.

COMMITTEE ACTION: Reject the public comment
COMMITTEE STATEMENT:
The public comment lacks technical substantiation to limit the support spacing of product conveying ducts to 10 feet. Furthermore, the 10 feet duct support spacing requirement is not applicable to all applications as it only applies to specific commercial applications.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
RECOMMENDATION:
Revise text as follows:

507.1 Exhaust System. Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system in accordance with the equipment and performance requirements of this chapter. [NFPA 96:4.1.1] Such equipment and performance shall be maintained in accordance with this chapter during periods of operation of the cooking equipment. Specifically, the following equipment shall be kept in good working condition:

1. Cooking equipment
2. Hoods
3. Ducts (where applicable)
4. Fans
5. Fire suppression -extinguishing systems equipment
6. Special effluent or energy control equipment [NFPA 96:4.1.2, 4.1.3]

Airflows shall be maintained. [NFPA 96:4.1.4] Maintenance and repairs shall be performed on components at intervals necessary to maintain these good working conditions [NFPA 96:4.1.3.1]:

1. The responsibility for inspection, testing, maintenance, and cleanliness of the ventilation control and fire protection of the commercial cooking operations shall be the ultimate responsibility 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]

508.2.8 Insulation Flame Spread Rating. Insulation materials other than electrical insulation shall have a flame spread rating of 25 or less where tested in accordance with UL 723. [NFPA 96:5.1.9]

508.2.9 Adhesives or Cements. Adhesives or cements used in the installation of insulating materials shall be in accordance with the requirements of Section 508.2.8, where tested with the specific insulating material. [NFPA 96:5.1.10]

508.3 Insulation. Insulation materials other than electrical insulation shall have a flame spread rating index of not more than 25 or less 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 the preceding requirements this section where tested with the specific insulating material. [NFPA 96:5.1.9, 5.1.10]

509.1 Grease Removal Devices. Listed grease filters, listed baffles, or other approved listed grease removal devices for use with commercial cooking equipment 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 tested in accordance with UL 1046. Mesh filters shall not be used unless evaluated as an integral part of a listed exhaust hood or listed in conjunction with a primary filter in accordance with UL 1046. [NFPA 96:6.1]

509.2.3.1 Arrangement. Grease filters shall be tight fitting and firmly held in place and grease filters shall be arranged so that exhaust air passes through the grease filters. [NFPA 96:6.2.3.3]

509.2.3.2 Accessibility. Grease filters shall be easily accessible and removable for cleaning. [NFPA 96:6.2.3.4]

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 96:6.2.3.5]

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. The grease drip trays shall be kept to the minimum size needed to collect grease 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]

510.1 General. Ducts shall not pass through fire walls or fire partitions. [NFPA 96:7.1.1]

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 panels that are constructed and installed in accordance with Section 510.3.3.5. [NFPA 96:7.3.1, 7.3.2]

(remaining text unchanged)

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 collar within. This access panel shall be as close to the hood as possible but shall not exceed 18 inches (457 mm) of the damper. [NFPA 96:7.3.4]

(remaining text unchanged)

510.3.3.5 Fire Protection System Devices. Openings for installation, servicing, and inspection of listed fire protection system devices and for duct cleaning shall be provided in ducts and enclosures and shall be in accordance with the requirements of Section 510.3 through Section 510.3.2, and Section 510.7.4. Enclosure openings required to reach access panels in the ductwork shall be large enough for the removal of the access panel through the enclosure opening. [NFPA 96:7.4.4]

For SI units: 1 inch = 25.4 mm

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 510.5.2.1(1)
TELESCOPING -TYPE DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(a)]

510.6.1 Weather Protection. Ducts shall be protected on the exterior by paint or other suitable weather-protective coating. Ducts constructed of noncorrosive 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 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 concealed spaces, to or through the roof, so as to maintain the integrity of the fire
510.7.1 Separations. The enclosure shall be sealed around the duct at the point of penetration of the lowest first fire-rated ceiling or floor above barrier after the hood, in order to maintain the fire resistance rating of the enclosure and shall be vented to the exterior of the building through weather-protected openings. [NFPA 96:7.7.1.2 - 7.7.1.4]

510.7.1.1 Less than Four Stories. Where the building is less than four stories in height, the enclosure wall shall have an enclosure with a fire resistance rating of not less than 1 hour. [NFPA 96:7.7.2.1.1]

510.7.1.2 Four Stories or More. Where the building is four stories or more in height, the enclosure wall shall have an enclosure with a fire resistance rating of not less than 2 hours. [NFPA 96:7.7.2.1.2]

510.7.2 Protection from Physical Damage. Measures shall be taken to prevent physical damage to a covering or enclosure material. A damage to the covering or enclosure shall be repaired, and the covering or enclosure shall be restored to meet 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]

510.7.4 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 panels shall be readily accessible.

510.8.1 Rooftop Terminations. Rooftop terminations shall be arranged with or provided with the following [NFPA 96:7.8.2.1]:

(1) Not less than 10 feet (3048 mm) of horizontal clearance from the outlet to adjacent buildings, property lines, and air intakes. [NFPA 96:7.8.2.1(1)] Where space limitations absolutely prevent a 10 foot (3048 mm) horizontal separation from an air intake, a vertical separation shall be permitted, with the exhaust outlet being not less than 3 feet (914 mm) above an air intake located within 10 feet (3048 mm) horizontally.

(remaining text unchanged)
511.3 Replacement Air. Replacement air quantity shall be sufficient approved to 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. [NFPA 96:8.3]

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, with a standby power supply provided except as permitted in accordance with Section 513.7.1. [NFPA 96:10.7.1]

513.8.1 Single Device. A single device 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]

513.9 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 electrical 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]

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 periodically with employees by the management. [NFPA 96:11.1.4]

514.1.5 Nonoperational. Cooking equipment shall not be operated while its fire-extinguishing system or exhaust system is nonoperational or otherwise impaired. [NFPA 96:11.1.6]

514.2.1 Requirements. Actuation and control components, including remote manual pull stations, mechanical and electrical devices, detectors, and actuators shall be checked tested for proper operation during the inspection in accordance with the manufacturer’s instructions. In addition to these requirements, the specific inspection and maintenance requirements of the extinguishing system standards as well as the applicable listed 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 Sprinkler Heads. Fusible links of metal alloy type and automatic sprinkler heads of metal alloy type shall be replaced not less than semiannually except as permitted by Section 514.2.3 and Section 514.2.4. [NFPA 96:11.2.4]

514.2.3 Inspection Tag. The year of manufacture and the date of installation of the fusible links shall be marked on the system inspection tag. The tag shall be signed or initialed by the installer. [NFPA 96:11.2.5, 11.2.5.1]

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, and replaced where necessary in accordance with the manufacturer’s instructions every 12 months or more frequently to ensure operation of the system as designed. [NFPA 96:11.2.7]

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

<table>
<thead>
<tr>
<th>TYPE OR VOLUME OF COOKING</th>
<th>INSPECTION FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FREQUENCY</td>
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(portions of table not shown remain unchanged)
514.4 Cleaning of Exhaust Systems. Upon inspection, where 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 trained, qualified, and certified company or person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.6.1]

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 or both. [NFPA 96:11.6.14]

516.2.1 Gas/Electrically Fueled Cooking Appliances. Gas-fueled or electrically fueled cooking appliances shall be used. [NFPA 96:13.2.1] Listed gas-fueled appliances equipment designed for use with specific recirculating systems shall not have the combustion flue outlet(s) directly connected to the recirculating system in the intended manner. Gas-fueled appliances shall have not less than a 18 inches (457 mm) of clearance from the flue outlet to the filter inlet in accordance with Section 509.2, and shall be in accordance with the installation requirements of NFPA 54 or NFPA 58. [NFPA 96:13.2.1 -13.2.3]

516.2.3 Protection. Cooking appliances that require protection and that are under a recirculating hood shall be protected by either the integral fire protection system for the hood or a system in accordance with UL 710B or Section 513.0. [NFPA 96:13.2.4.2]

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]

517.7 Fire-Extinguishing Equipment for Solid-Fuel Cooking. Approved fire-extinguishing equipment shall be provided to protect solid-fuel-burning cooking appliances that might be a source of ignition of grease in the hood, grease removal device, or duct. Exception: Where acceptable to the Authority Having Jurisdiction, solid-fuel-burning cooking appliances constructed of solid masonry or reinforced portland or refractory cement concrete and vented in accordance with NFPA 211, Chapter 3, and Chapter 4, shall not require fixed automatic fire-extinguishing equipment. [NFPA 96:14.7.2]

517.7.1 Grease Removal Devices, Hoods, and Duct Systems. Approved 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-burning cooking appliances constructed of solid masonry or reinforced portland or refractory cement concrete and vented in accordance with NFPA 211, Chapter 3, and Chapter 4, 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 Standard. Approved fire-extinguishing equipment for solid-fuel-burning cooking appliances, where required, shall be in accordance with NFPA 211, Section 513.0 and shall be comprised of use water-based agents. [NFPA 96:14.7.5]

517.7.3 Rating and Design. Fire-extinguishing equipment shall be rated and designed to extinguish solid-fuel cooking fires, in accordance with the manufacturer’s instructions. 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 96:14.7.6, 14.7.7]

517.7.4 Listing/Class. Solid-fuel appliances (whether or not under a hood) with fire boxes of 5 cubic feet (0.1 m³) volume or less shall have a listed 2-A rated water-type 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) from to the appliance. [NFPA 96:14.7.8]

SUBSTANTIATION:
1. Sections 507.1, 508.3, 509.1, 509.2.3.1, 509.2.3.2, 509.2.3.3, 509.2.4, 509.2.4.1, 510.1, 510.3, 510.3.1, 510.3.3.5, 510.6.1, 510.7, 510.7.1.1, 510.7.1.2, 510.7.2.2, 510.7.4, 510.8.1, 511.1.4, 511.2.3, 511.3, 513.7, 513.8.1, 513.9, 514.1.3, 514.1.5, 514.2.1, 514.2.2, 514.2.3, 514.2.4, 514.3, 514.4, 514.4.13, 516.2.1, 516.2.3, 516.5.1, 517.7, 517.7.1, 517.7.2, 517.7.3, 517.7.4, Figure 510.5.2.1(1), Figure 511.1.2(4), and Table 514.3 are being revised to correlate with NFPA 96-2011.

2. Sections 508.2.8 and 508.2.9 are being deleted as the extraction is duplicated in Section 508.3.

COMMITTEE ACTION: Accept as Amended by the TC

Amend proposal as follows:
511.3 Replacement Air. Replacement air quantity shall be approved to 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. [NFPA 96:8.3]

COMMITTEE STATEMENT:
The text “be approved” was deleted as it will create confusion and will give the impression that the air quantity must first be approved by the AHJ to prevent negative pressures.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

507.0 General Requirements.
507.1 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 the equipment and performance requirements of this chapter. [NFPA 96:4.1.1]
Such equipment and its performance shall be maintained in accordance with the requirements of this chapter during periods of operation of the cooking equipment. The following equipment shall be kept in good 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 96:4.1.2, 4.1.3]
Airflows shall be maintained. [NFPA 96:4.1.4] Maintenance and repairs shall be performed on components at intervals necessary to maintain good working conditions as follows [NFPA 96:4.1.2.1]:
(1) Airflows shall be maintained. [NFPA 96:4.1.4]
(2) The responsibility for inspection, testing, maintenance, and cleanliness of the ventilation control and fire protection of the commercial cooking operations shall ultimately be the responsibility 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]
(3) Solid-fuel cooking equipment shall comply with the requirements of Section 517.0. [NFPA 96:4.1.6]
(4) Multiple-tenant 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]
(5) Interior surfaces of the exhaust system shall be accessible for cleaning and inspection purposes. [NFPA 96:4.1.8]
(6) Cooking equipment used in fixed, mobile, or temporary concessions, such as trucks, buses, trailers, pavilions, tents, or a form of roofed enclosure, shall be in accordance with this chapter unless all or part of the installation is otherwise exempted by the Authority Having Jurisdiction. [NFPA 96: 4.1.2.4.1.9]

507.3.2.2 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]

507.3.2.3 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]
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. [NFPA 96:5.4]

508.12 List 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 be in accordance with Section 510.0. Ultraviolet hoods shall comply with UL 710. [NFPA 96:5.5]

508.2.2 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]

508.2.3 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]

508.4.4 Construction of Type I Hoods. The hood or that portion of a primary collection means designed for collecting cooking vapors and residues constructed of steel shall be not less than 0.04348 of an inch (1.09219 mm) (No. 18 MSG), stainless steel not less than 0.0376 of an inch (0.914 mm) (No. 20 MSG) in thickness, or other approved material of equivalent strength and fire and corrosion resistance.

Exception: Listed exhaust hoods.

508.7.2 Duct Construction 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 508.7.2. [NFPA 96:5.1.8.1]

FIGURE 508.7.2 Duct Construction Eyebrow-Type Hoods
508.3 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]

508.10 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, Section 508.7, and Section 508.9. [NFPA 96:5.3.1]

508.10.1 Outer Shell. The construction of the outer shell or the inner exhaust shell shall be in accordance with Section 508.1 and Section 508.2. [NFPA 96:5.3.2]

508.10.3.3 Exemption. 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. [NFPA 96:6.1.1, 6.1.2]

509.1 Grease Filters-Mesh Type. Mesh filters shall not be used unless evaluated as an integral part of a listed exhaust hood or listed in conjunction with a primary filter in accordance with UL 1046. [NFPA 96:6.1.3]

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, where the distance between the grease removal device and the appliance flue outlet (heat source) is less than 18 inches (457 mm). [NFPA 96:6.2.2.1]
509.2.3.1 Arrangement. Grease filters shall be arranged so that exhaust air passes through the grease filters. [NFPA 96:6.2.3.44]

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 96:6.2.3.56]

510.1.1 Fire Hazards. Ducts shall lead as directly as is practicable to the exterior of the building, so as not to unduly increase a fire hazard. [NFPA 96:7.1.2]

510.1.3 Duct Installation. Ducts shall be installed with not less than 2 percent slope on horizontal runs up to 75 feet (22 860 mm) and not less than 8 percent slope on horizontal runs more than 75 feet (22 860 mm). Factory-built grease ducts shall be permitted to be installed in accordance with the listing and the manufacturer’s installation instructions. 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. Ducts shall be installed without forming dips or traps that might collect residues. [NFPA 96:7.1.4.1] In manifold (common duct) systems, the lowest end of the main duct shall be connected flush on the bottom with the branch duct. [NFPA 96:7.1.4.5]

Duct systems serving a Type I hood shall be so constructed and installed that grease cannot become pocketed in a portion thereof, and the system shall slope not less than \( \frac{1}{4} \) inch per lineal foot (20.8 mm/m) toward the hood or toward an approved grease receptacle. Where horizontal ducts exceed 75 feet (22 860 mm) in length, the slope shall be not less than 1 inch per lineal foot (83.3 mm/m).

510.2.1.7 Installation Grease Ducts. (remaining text unchanged)

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 panels that are constructed and installed in accordance with the requirements of Section 510.3.3. [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 entry or discharge. [NFPA 96:7.3.3]

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 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]

510.3.4 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 where not easily accessible from a 10 foot (3048 mm) stepladder. [NFPA 96:7.4.1.3]

510.3.5 Vertical Ducts. (remaining text unchanged)

510.3.5.1 Access. (remaining text unchanged)

510.3.5.2 Safe Access and Work Platform. Where not easily accessible from 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 Nonlisted Ductwork. (remaining text unchanged)

510.3.6 Access Panels. Access panels shall be of the same material and thickness as the duct (Section 510.5.4). Access panels shall have a gasket or sealant that is rated for 1500°F (816°C) and shall be greasetight. 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.

Exception: Listed grease duct access door assemblies (access panels) shall be installed in accordance with their terms of the listings and the manufacturer’s installation instructions. [NFPA 96:7.4.3]
510.5.1 Materials. Ducts shall be constructed of and supported by carbon steel not less than 0.054 of an inch (1.37 mm) (No. 16 MSG) in thickness or stainless steel not less than 0.043 of an inch (1.09 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 nonwelded 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 Duck 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]

510.5.3.3 Inside Duct Section Telescoping and Bell-Type Connections. (remaining text unchanged)

510.6 Exterior Installations. The exterior portion of the ductwork shall be vertical wherever possible and shall be installed and adequately 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 507.3. [NFPA 96:7.6.1 - 7.6.3]

510.7 510.8 Interior Installations. In 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 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 507.3.4 through Section 507.3.6) 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 their listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.1.5]

510.8.3 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 507.3.2 through Section 507.3.3 and 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 their listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.2.2.4]

510.8.4.2 Protection from Physical Damage. Measures shall be taken to prevent physical damage to a covering or enclosure material. 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]
510.8.4.3 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 approved for continued operation, and acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.3.3]

510.7.4 510.8.6 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 panels fire door shall be readily accessible, aligned, and of a size to allow access to the rated access panels on the ductwork. [NFPA 96:7.7.4.4]

510.8.7 Fire Zone Ducts with Enclosure(s). Each duct system shall constitute an individual system serving 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]

510.8.1 510.9.1 Rooftop Terminations. Rooftop terminations shall be arranged with or provided with the following: [NFPA 96:7.8.2.1(1)]

(1) Not less than 10 feet (3048 mm) of horizontal clearance from the outlet to adjacent buildings, property lines, and air intakes. [NFPA 96:7.8.2.1(1)] Where space limitations absolutely prevent a 10 feet (3048 mm) horizontal separation from an air intake, a vertical separation shall be permitted, with the exhaust outlet being not less than 3 feet (914 mm) above an air intake located within 10 feet (3048 mm) horizontally.

(2) Not less than 5 feet (1524 mm) of horizontal clearance from the outlet (fan housing) to a combustible structure.

(3) A vertical separation of 3 feet (914 mm) below an exhaust outlet for air intakes within 10 feet (3048 mm) of the exhaust outlet.

(2) The exhaust flow is directed up and away from the surface of the roof and not less than 40 inches (1016 mm) above the roof surface.

(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 grease collection container that is noncombustible, closed, rainproof, and structurally sound for the service to which it is applied, and will not sustain combustion.

(5) A grease collection device that is applied to exhaust systems shall not inhibit the performance of a fan. [NFPA 96:7.8.2.1(5)]

Exception: Grease containers that are evaluated for equivalency with the preceding requirements and listed as such.

(6) A listed grease collection system that is in accordance with Section 510.9.1(4) and Section 510.9.1(5).

(7) A listed grease duct listed in accordance with Section 510.4, 507.3.7 or with ductwork constructed in accordance with Section 510.5.

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

(a) Where the fan attaches to the ductwork, provided the ductwork extends not less than 18 inches (457 mm) above the roof surface, as shown in Figure 510.9.1.

(b) The fan discharges not less than 40 inches (1016 mm) above the roof surface, as shown in Figure 511.1.1. (See Section 511.1.[1]) [NFPA 96:7.8.2.1(8)]

(2) Other approved fan, provided it is in accordance with the following criteria:

(a) The fan is in accordance with the requirements of Section 510.9.1(4) and Section 511.1.3.

(b) Its discharge or its extended duct discharge meets in accordance 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(9)]

FIGURE 511.1.1510.9.1
UPBLAST FAN CLEARANCES
[NFPA 96: FIGURE 7.8.2.1]

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. (See 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 installed in accordance shall comply with Section 510.3.3 through Section 510.3.7, or other ducts constructed in accordance shall comply with Section 510.5.

(5) An approved fan, provided it meets 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]

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. (See Figure 511.1.1) Installation shall comply with the requirements of with 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 grease-tight housing. They 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 96:8.1.23.1 – 8.1.23.3]

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 an easily accessible area of approved 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 96:8.1.23.4 – 8.1.23.6]

511.1.3 At the Rooftop. Fans installed at the rooftop termination point shall be in accordance with the following:

(1) Section 510.9.1(1) and Section 510.9.1.2. [NFPA 96:8.1.3.1]

(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). [NFPA 96:8.1.34.6]

511.1.3.2 Within the Building. Fans installed within the building shall be in accordance with the following:

(1) Located in an easily accessible area of adequate size to allow for service or removal. [NFPA 96:8.1.34.2]

(2) Flexible connectors shall be prohibited. [NFPA 96:8.1.34.5]

(3) A drain shall be directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L). [NFPA 96:8.1.34.6]

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 96:8.1.34.3, 8.1.34.4]

511.1.4 Construction. Exhaust fan housings shall be constructed of carbon steel not less than 0.04460 of an inch (1.127254 mm) (No. 16 MSG) in thickness, of stainless steel not less than 0.04348 of an inch (1.097119 mm) (No. 18 MSG) in thickness, or, where listed, in accordance with the terms of the listing. [NFPA 96:8.1.45]

511.1.5 Miscellaneous 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 507.3, or Section 510.8.3 through Section 510.8.4.1 where installed within an enclosure. [NFPA 96:8.1.56.1, 8.1.56.26.2]

511.1.6 Standard. Wiring and electrical equipment shall comply with NFPA 70. [NFPA 96:8.1.67]

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.
511.2.3 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 where the exhaust fan and cooking equipment served by the fan have been shut down. The exhaust fan shall be provided with a means so that the fan is activated when an appliance under the hood is turned on. [NFPA 96:8.2.3]

512.2.1 Device Installation in Ducts. Where specifically listed for such use, 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 where specifically listed for such use. [NFPA 96:9.2.2]

512.3 Other Equipment. Fume incinerators, thermal recovery units, air pollution control devices, or other devices shall be permitted to be installed in ducts, hoods, or to be located in the path of travel of exhaust products where specifically approved listed for such use. [NFPA 96:9.3.1] Downgrading other parts of the exhaust system due to the installation of these approved devices, whether listed or not, shall not be allowed permitted. [NFPA 96:9.3.1, 9.3.2]

513.1.1 Protection. Cooking equipment that produces grease-laden vapors (such as, but not limited to, deep-fat fryers, ranges, griddles, broilers, woks, tilting skillets, and braising pans) and can be 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]

513.2.2 Standard. Automatic fire-extinguishing systems shall be installed in accordance 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 Existing Systems. In existing systems, where changes in the cooking media, positioning, or replacement of cooking equipment occur, the fire-extinguishing system shall be made in accordance with Section 513.2.2. [NFPA 96:10.2.3.1]

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 controlled individually. [NFPA 96:10.2.9]

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]

513.4.2 Protection Not Required. A gas appliance not requiring protection, but located under the same ventilating equipment where protected appliances are located, shall also be automatically shut off upon activation of the extinguishing system. [NFPA 96:10.4.3]

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, 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 A manual actuation device shall be located not less than 10 feet (3048 mm) where
possible and less not more than 20 feet (6096 mm) from the protected exhaust system(s) kitchen appliance(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 not more than 40 pounds-force (lbf) (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 513.5.1. [NFPA 96:10.5.1 – 10.5.2]

513.3 Manual Actuator(s). The means for manual actuator activation shall be mechanical or rely on electrical power for activation in accordance with Section 513.5.4. [NFPA 96:10.5.5]

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, animal oils, and fats. Such extinguishers shall use agents that saponify upon contact with hot grease in accordance with NFPA 10 (Class K extinguishers). [NFPA 96:10.10.1, 10.10.2]

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

514.1.7 Inspection Frequency. Inspection and maintenance of “other equipment” as allowed in Section 512.3 shall be conducted by 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. (remaining text unchanged)

514.2.1 Requirements. 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. In addition to these requirements, 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 Heads. Fusible links of the metal alloy type and automatic sprinklers heads of the metal alloy type shall be replaced not less than semiannually except as permitted by Section 514.2.3 and Section 514.2.4. [NFPA 96:11.2.4]

514.2.3 Inspection Tag. The year of manufacture and the date of installation of the fusible links shall be marked on the system inspection tag. The tag shall be signed or initialed by the installer. [NFPA 96:11.2.5, 11.2.5.1]

Detection devices that are bulb-type automatic sprinklers and fusible links other than the metal alloy type shall be examined and cleaned or replaced annually. [NFPA 96:11.2.5, 11.2.5.1, 11.2.6]

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 trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.6.1]

515.3.1 514.5 Cooking Equipment Maintenance. (remaining text unchanged)

515.3.1 514.5.1 Cleaning. (remaining text unchanged)

515.1.1 Installation. 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]

515.1.1.1 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]

515.1.1.2 Prior Location. The fire-extinguishing system shall not require re-evaluation where the cooking appliances are moved for the purpose of perform maintenance and cleaning, provided the appliances are returned to approved design location prior to cooking operations, and disconnected fire-extinguishing system nozzles attached to the appliances are reconnected in accordance with the manufacturer’s instructions and listing. [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 with the following:

1. The clearance requirements of Section 507.3.
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:** References to ducts in 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]

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]

516.3.4 Minimum 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. This device shall open the interlock circuit where the airflow falls 25 percent below the system’s normal operating flow or 10 percent below its listed minimum rating, whichever is lower. This airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:13.3.5.1 - 13.3.5.3]

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]

517.1.1 Natural Draft. Where solid-fuel cooking equipment is required by the manufacturer’s instructions to have a natural draft, the vent shall be in accordance with Section 517.4. [NFPA 96:14.1.1]

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]

517.3.1 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]

**Exception:** Cooking equipment not requiring automatic fire-extinguishing equipment (in accordance with the provisions of 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]

517.3.1.1 Equipment with Solid Fuel for Flavoring. Gas-operated equipment utilizing solid fuel for flavoring that is in accordance with 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 burner.
3. Spark arresters that are in accordance with Section 517.1.6 shall be provided.
4. The maximum quantity of solid fuel consumed shall not exceed 4.5 pounds (2.04 kg) per hour per 10 000 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.
gas-operated equipment with integral solid fuel holder(s) intended for flavoring, such as a radiant charbroiler(s), shall comply with the requirements of UL 300 that address the gas radiant charbroiler(s) and mesquite wood charbroiler(s).

A fire suppression system nozzle(s) shall be installed to protect the solid fuel holder.

The fire suppression system shall be designed and installed to protect the entire cooking operation.

The solid fuel holder shall be limited to a size of 2000 cubic inches (0.0328 m³), with no dimension to exceed 20 inches (508 mm).

A maximum of one solid fuel holder for each 100,000 Btu/hr (29 kW), or portion thereof, of burner capacity shall be permitted.

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

517.5.1 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 duct system. [NFPA 96:14.5.2]

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

517.7 Fire-Extinguishing Equipment for Solid-Fuel Cooking. Listed fire-extinguishing equipment shall be provided to protect solid-fuel-burning cooking appliances that produce grease-laden vapors shall be protected by listed fire-extinguishing equipment might be a source of ignition of grease in the hood, grease removal device, or duct.

**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, Chapter 3, and Chapter 4, shall not require fixed automatic fire-extinguishing equipment. [NFPA 96:14.7.1, 14.7.2]

517.7.1 Grease Removal Devices, Hoods, and Duct Systems. Approved 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, Chapter 3, and Chapter 4, shall not require automatic fire-extinguishing equipment for the protection of grease removal devices, hoods, and duct systems. [NFPA 96:14.7.4]

517.7.4 Listing/Class. Solid-fuel appliances (whether or not under a hood) with fireboxes of 5 cubic feet (0.1 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 96:14.7.8]

517.7.6 Fuel Storage. Fuel storage areas shall be provided with a sprinkler system that is installed in accordance with NFPA 13 except where permitted in accordance with the following:

1. Where approved by 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 the parts of the areas.

2. In lieu of the sprinkler system outlined in Section 517.7.5, 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 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 (0.1 m³). [NFPA 96:14.9.2.8-9.2.8.2]

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]
517.8.3 Prohibition. No solid-fuel cooking device 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 a deep-fat frying unit. [NFPA 96:14.9.4.5]

518.0 Down Draft Appliances.
518.1 General. The downdraft appliance ventilation system for a down draft appliance shall be capable of capturing and containing the effluent discharge from the appliance(s) it is serving. [NFPA 96:15.1.2]

518.2 Fire-Extinguishing Equipment. Fire-extinguishing equipment for on a down draft appliance ventilation system shall comply with the following:
1. Cooking surface, duct, and plenum protection shall be provided.
2. Not less than one fusible link or heat detector shall be installed within the exhaust duct opening in accordance with the manufacturer’s listing.
3. A fusible link or heat detector shall be installed provided above the protected cooking appliance and in accordance with the extinguishing system manufacturer’s listing.
4. A manual activation device shall be installed provided as part of the 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 Airflow Switch or Transducer. An airflow switch or transducer shall be installed provided after the last filter component to ensure that a minimum airflow is maintained. [NFPA 96:15.3.1]

203.0 Automatic. That which provides performing a function without the necessity of human intervention. [NFPA 96:3.3.7]

204.0 Baffle Plate. An object placed in or near an appliance to change the direction of or to retard the flow of air, air-fuel mixtures, or flue gases. [NFPA 96:3.3.8]

205.0 Closed Combustible Construction. Combustible building construction, including walls, structural framing, roofs, roof ceilings, floors, and floor-ceiling assemblies, continuously enclosing a grease duct on four sides where one or more sides require protection in accordance with Section 507.3 are protected. [NFPA 96:3.3.14.1]

Concealed Spaces. That portion(s) of a building behind walls, over suspended ceilings, in pipe chases, and in attics, and elsewhere whose size might normally range from 1 3/4 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. [NFPA 96:3.3.47.1] Such spaces have sometimes been used as HVAC plenum chambers.

206.0 Dips. Depression or cup like places in horizontal duct runs in which liquids could accumulate. [NFPA 96:3.3.18]

206.0 Fire Resistance Rating. The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of ASTM E119 or UL 263. [NFPA 96:3.3.25]

209.0 Grease Removal Devices. A system of components designed for and intended to process vapors, gases, or air, or both 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. [NFPA 96:3.3.44.20]

214.0 Limited-Combustible Material. Refers to a building construction material with limited burning characteristics that, where in the form in which it is used, does not comply with the definition of noncombustible, 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 \( \frac{1}{8} \) 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. [NFPA 96:3.3.38]

216.0

Noncombustible. A substance that will not ignite and burn under the conditions anticipated where subjected to a fire. 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 E 136 are considered noncombustible material. [NFPA 220:3.3.4]

2. Material having a structural base of noncombustible material as defined in 1 above, with a surfacing material not over \( \frac{1}{8} \) of an inch (3.2 mm) thick that has a flame-spread index not higher than 50.

Noncombustible does not apply to surface finish materials. Material required to be noncombustible for reduced clearances to flues, heating appliances, or other sources of high temperature shall refer to material in accordance with 1 above. No material shall be classified 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 conditions. [NFPA 96:3.3.37.3]

217.0

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 507.3 are protected. [NFPA 96:3.3.14.2]

219.0

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. [NFPA 96:3.3.41]

222.0

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 96:3.3.2019]

SUBSTANTIATION:
Chapter 5 is being modified to correlate with NFPA 96-2014 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Reject the public comment (Failed Ballot)

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 13 NEGATIVE: 8 NOT RETURNED: 1 Garza

Note: Item # 102 failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-4.6.4 of the Regulations Governing Committee Projects, the TC action shall be reported in the ROC as rejected.
EXPLANATION OF NEGATIVE:

BERGER, CARROLL, DIAS, RAMOCIOTTI, RIBBS: This proposal goes beyond the scope of the original code change submitted. The definitions removed prescribed needed language and therefore the code will be in potential conflict with the building codes due to vague and unenforceable requirements.

CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (various definition changes and deletions) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”

FEEHAN: This comment is beyond the scope of the original code proposal submitted. I believe the changes to the language in the comment are good. However, the changes and deletion of definitions removes necessary language.

MANN: I believe the proposal goes beyond the scope of the code change as originally submitted. The definitions remove needed prescriptive language. Furthermore, with vague and unenforceable requirements there is potential conflict with building codes.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 54)

RECOMMENDATION:
Revise text as follows:

508.2.10 507.2 Listed Devices. Penetrations shall be sealed with listed devices in accordance with the requirements of Section 508.2.11 507.2.1. [NFPA 96:5.1.11]

508.2.11 507.2.1 Hood Penetration. Devices that require penetration of the hood, such as pipe and conduit penetration fittings and fasteners, shall be listed in accordance with UL 1978. [NFPA 96:5.1.12] Seams, joints, and penetrations of the hood enclosure shall comply with Section 508.2. Seams, joints, and penetrations of the ductwork shall comply with Section 510.5.2.

(renumber remaining sections)

SUBSTANTIATION:
The requirements in Section 508.2.10 and Section 508.2.11 are applicable for exhaust hoods and the ductwork. Therefore, Section 508.2.10 and Section 508.2.11 should be relocated to the general requirements of the chapter as opposed to indicating the same requirement in two separate sections, for hoods and for ductwork. Reference to the corresponding sections pertaining to seams, joints, and penetrations for the hood is being made for ease of use of the code.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

507.2.1 Penetration. Devices that require penetration of the hood, such as pipe and conduit penetration fittings and fasteners, shall be listed in accordance with UL 710 or UL 1978. [NFPA 96:5.1.12] Seams, joints, and penetrations of the hood enclosure shall comply with Section 508.2. Seams, joints, and penetrations of the ductwork shall comply with Section 510.5.2.

COMMITTEE STATEMENT:
Section 507.2.1 was modified to include UL 710 as it is an applicable standard approved for use within this section, and is referenced in Table 1701.0.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Marguerite Carroll, UL, LLC

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

507.2.1 Penetration. Devices that require penetration of the 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 508.2. Seams, joints, and penetrations of the ductwork shall comply with Section 510.5.2.

SUBSTANTIATION:
Section 507.2.1 should be modified to clarify that the penetrations that are in accordance with UL 710 (Type 1 hoods) and UL 1978 (grease ducts) are applicable only to hoods and ductwork used for grease applications.
COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 55)

RECOMMENDATION:
Revise text as follows:

508.1 Where Required. Hoods shall be installed at or above commercial-type deep-fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, grease, or heat 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 has been 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) (5.0 E-06 kg/m³) where operated with a total airflow of 500 cubic feet per minute (cfm) (0.236 m³/s).

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 in accordance with EPA Test Method 202, with the system operating at its minimum listed airflow.

(3) – (5) (remaining text unchanged)

TABLE 1701.0
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>EPA 202-1996 (R2010)</td>
<td>Determination of Condensable Particulate Emissions for Stationary Sources</td>
<td>Miscellaneous</td>
<td>508.1(1), 516.2.9(2)</td>
</tr>
</tbody>
</table>

SUBSTANTIATION:
EPA 202 is being deleted from the UMC as it is a government regulation and not a standard as defined in IAPMO's Regulations Governing Committee Projects.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

508.1 Where Required. Hoods shall be installed at or above commercial-type deep-fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, grease, or heat 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 has been 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) (5.0 E-06 kg/m³) where operated with a total airflow of 500 cubic feet per minute (cfm) (0.236 m³/s).

(2) (remaining text unchanged)
COMMITTEE STATEMENT:
Section 508.1 was modified to include UL 710B as it is the applicable standard approved for use within this section, and is referenced in Table 1701.0.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

508.1 Where Required. Hoods shall be installed at or above commercial-type deep-fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, grease, or heat 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 has been listed in accordance with UL 197 for reduced emissions shall not be required to be provided with an exhaust system. The listing evaluation of the cooking equipment shall demonstrate that the grease discharge at the exhaust duct of a test hood placed over the appliance shall 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). [NFPA 96: 4.1.1.1 - 4.1.1.2]
(2) Recirculating systems listed in accordance with UL 710B and installed in accordance with Section 516.0.

SUBSTANTIATION:
This proposal was revised by the TC to include reference to UL 710B. However, UL 710B is a standard that addresses recirculation systems, which is already addressed in Exception 2. Exception 1 pertains to only commercial electric cooking appliances with an emitted effluent not exceeding 2.9 E-09 ounces per cubic inch as measured in accordance with EPA 202. Therefore, the correct reference standard should be UL 197 as it addresses electrical cooking appliances that are in accordance with EPA 202, and is consistent with the requirements of NFPA 96. Furthermore, the language was revised to correlate with NFPA 96-2014 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
UL 197 is the incorrect standard to be referenced; the correct standard is UL 710B as it addresses reduced emissions requirements.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2:
SUBMITTER: Thomas Johnson, JDP, Inc.

RECOMMENDATION:
Request to replace the code change proposal by this public comment.
508.0 Hoods.

508.1 Where Required. Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that emits comparable amounts of steam, smoke, grease, or heat 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) – (2) (remaining text unchanged)

SUBSTANTIATION:
The production of smoke and grease vapors do not comprise the hazard to which the code seeks intervention remedy. Rather, it is the emission of smoke and grease vapors beyond 5 mg/m³ of condensable particulates at a nominal exhaust rate of 500CFM, pursuant to EPA 202 as referenced in Chapter 13 of NFPA 96, that drive the requirement for a Type I exhaust system and when a Type I hood is required.

Recirculating hood systems capture and contain whatever effluent a cooking process emits, and then it filters process emissions to ensure that what is emitted via recirculation into the space from the discharge of the recirculating system, is an emission effluent concentration less than the threshold limit value (TLV) for condensable particulates as established in NFPA 96 Chapter 13. The ANSI performance certification test for compliance with NFPA 96 Ch 13 criteria is ANSI UL 710B.

In a similar manner, appliances with integral grease emission limiting devices (e.g., integral catalytic combustion chambers) are proven to emit condensable particulates at rates less than the TLV established in NFPA 96 and accordingly, do not fall within the scope of processes where a Type I hood is required. UL KNLZ equipment may produce smoke and grease vapors internally, but those condensable particulates are converted to carbon dioxide (CO₂) and water (H₂O) in their integral catalytic combustion chambers and PASS to the UL KNLZ PROVES beyond a reasonable doubt that their emissions are less than the NFPA 96 TLV. The amount of water vapor emitted per cycle is less than a gram, roughly 1/8 of that of brewing a single pot of coffee.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Joel F. Hipp
Hobart Corporation

RECOMMENDATION:
Revise text as follows:

508.0 Hoods.
508.1 Where Required. Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotissieres, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, grease, or heat 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) – (2) (remaining text unchanged)
(3) Appliances with a separate duct system.
(4) Appliances that include a vapor recovery system listed in accordance with UL 921 and installed in a facility where the HVAC system is capable of accommodating the latent and sensible heat loads from such appliances.

SUBSTANTIATION:
(Attachments for Item 106 are included in the substantiation CD presented to the TC)

New Exception (3): Examples of separate duct systems include a direct vented appliance and pant-leg connectors at the ends of a conveyor dishmachine.

New Exception (4): There are many multi-story or historic buildings that present challenges for construction of vent systems. There have been, and will continue to be, innovative advancements in technology that result in highly efficient, energy-conserving products that do not require a dedicated vent hood. Installing a Type II hood when clearly not needed results in unnecessary installation expense and wasted energy by heating and cooling make-up air. With the proposed change, the Mechanical Engineer on record can provide a report showing the HVAC system will handle the latent and sensible heat loads of the appliances without a vent hood. This proposal would help move the code away from prescriptive language that is design restrictive and move it towards a performance based code that provides more opportunities for real improvements in reducing carbon footprints. Independent tests on these appliances show the total convective heat load can be reduced by 40% or more during operation. The table below shows a summary of an independent test for the heat output from a commercial door-type dishwasher. The complete test report is attached (HobartReport5011 09 07Jan2010.pdf).

![Table 2. Data Summary for Testing During Washing Operation](image)

<table>
<thead>
<tr>
<th></th>
<th>Low Temperature Chemical Sanitizing</th>
<th>High Temperature Sanitizing with Condensing Unit</th>
<th>High Temperature Sanitizing without Condensing Unit (i.e., Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Convective Heat Load [Btu/h]</td>
<td>17,100</td>
<td>17,800</td>
<td>29,400</td>
</tr>
<tr>
<td>Sensible Heat Load [Btu/h]</td>
<td>3,900</td>
<td>4,800</td>
<td>8,000</td>
</tr>
<tr>
<td>Latent Heat Load [Btu/h]</td>
<td>13,200</td>
<td>13,000</td>
<td>21,400</td>
</tr>
<tr>
<td>Average Maximum Wash Tank Water Temperature (°F)</td>
<td>129</td>
<td>150</td>
<td>155</td>
</tr>
<tr>
<td>Average Rinse Water Temperature (°F)</td>
<td>125</td>
<td>185</td>
<td>181</td>
</tr>
<tr>
<td>Average Drain Water Temperature (°F)</td>
<td>125</td>
<td>142</td>
<td>155</td>
</tr>
<tr>
<td>Water Consumption (gal/rack)</td>
<td>0.68</td>
<td>0.76</td>
<td>0.64</td>
</tr>
</tbody>
</table>

The photographs below provide an example of the difference in operation of a vented appliance and a ventless appliance with a built-in condensing system.

There are several manufacturers of condensing dishwashers that have produced hundreds of machines in the last few years. These units are performing as designed in real world conditions. We believe this is the right time and place for a code improvement that helps get to net-zero energy buildings, achieve energy independence, and reduce greenhouse gas emissions.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The committee had concerns as to the types of appliances and hood configurations that are required to comply with the proposed language. Furthermore, the committee feels that the language is incomplete in regards to the description of the appliance and hood configurations. Lastly, the provisions should be written in more user friendly language and additional information should be submitted to support the validity of the proposed change.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Joel F. Hipp, Hobart, Div. ITW Food Equipment Group

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

508.0 Hoods.
508.1 Where Required. Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, grease, or heat 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. A Type II hood shall be permitted to be installed at or above dishwashers and cooking appliances that produce heat or do not produce grease or smoke in a food-processing establishment.

Exceptions:
(1) – (2) (remaining text unchanged)
(3) Dishwashing machines connected to a Type II duct system and exhausted directly to the outdoors.
(4) Dishwashing machines with a self-contained condensing system listed in accordance with UL 921 and installed in a facility where the HVAC system is sized to handle the latent and sensible heat load emitted from such appliances.
The Technical Committee rejected proposal Item # 106 because of concerns with the hood configuration. The modification to Exception 3 will resolve the Committee’s concerns. Furthermore, the Committee felt that the language needed to be written in a more user friendly format, and the replacement language has been written in a more user friendly format.

Section 508.1 should be revised due to the following problem:

**Problem:** There have been tremendous advances in the design of commercial dishwashers that can eliminate the need for a vent hood due to energy recovery technology that minimizes the amount of steam and heat emitted into the kitchen. Since the current wording of the code requires a hood over all dishwashers, the full benefits of innovations such as self-contained condensing systems can’t be realized by operators. Exceptions (1) and (2) allow cooking appliances to be installed without a Type I hood but there are currently no exceptions for Type II appliances that only produce steam and heat. The requirement for a hood over an appliance that produces “comparable amounts of steam” to a commercial dishwasher is not quantifiable since the energy consumed by the device resulting in a heat load on the kitchen can range anywhere from 2 kW to over 100 kW.

The mandate for the use of a Type II vent hood when technology obviates the need for such hoods has led to non-uniform code enforcement and numerous requests from IAPMO members for interpretation. In fact, a current entry in the IAPMO “ANSWERS AND ANALYSIS” forum states, “There are several pieces of kitchen equipment available that produce varying amounts of steam. It would be difficult to say that all steam tables require a Type II hood when there may not be enough steam escaping to be concerned. Additionally, most kitchen and restaurants move a tremendous amount of air that may be enough to compensate for small steam producing units. The decision to require a Type II hood would have to be made by the AHJ taking into account the amount of steam being produced by the equipment and the design of the air moving system serving the space.”

The following resolution is necessary to address this problem:

**Resolution:** Exception (3) is intended to clarify that dishwashing machines do not require an exhaust hood if they are connected to a Type II duct system that exhausts the heat and moisture loads directly to the exterior of the building. These are also known as “pant leg” ducts.

A conveyor dishwashing machine will typically have factory supplied vent cowls on the entrance and exit end that are provided with 4 inches by 16 inches connections to mate with the Type II duct system. The duct system will have an exhaust fan on the exterior of the building and the vent cowls will be balanced in accordance with manufacturer’s specifications. An example is shown in Figure 1 below:
Exception (4) is intended to accommodate technology that has emerged in recent years whereby the heat energy is transferred into the incoming cold water supply rather than exhausted, resulting in a 40% savings in energy consumption while absorbing latent heat and returning the condensed vapor to the dishmachine. Evidence that these units function as designed include field test results, an independent test report from the Commercial Kitchen Ventilation Lab and numerous state and city approvals. When the mechanical engineer on record submits a document declaring that the HVAC system will accommodate the latent and sensible heat output from the dishmachine, along with all other appliances in the kitchen, the result is the health and comfort of the occupants is protected at a level equivalent to that of a Type II hood.

A commercial dishwasher installed with a Type II vent hood will release approximately 60% of its total heat energy into the room. This is due to the inefficiency of the hood and the dishes air-drying outside the hood footprint. The mechanical engineer or HVAC contractor will include this value in sizing the kitchen exhaust and air-conditioning system.

A commercial dishwasher with energy recovery uses approximately 40% less energy than a machine without energy recovery, as shown in the attached third party test report. Thus a high-temperature energy recovery dishwasher without a hood disperses the same amount of latent and sensible heat into the kitchen as a standard high-temperature dishwasher with a hood. Since this heat emitted to the room is being accounted for by the HVAC system, there is an equivalent level of protection for public health and worker comfort.

The following supporting documents are provided for the TC for review:
(1) Summary field test data from a San Francisco school
(2) Independent Test Report
(3) Minnesota Mechanical Code Amendment

**COMMITTEE ACTION:** Accept the public comment as amended
Amend comment as follows:

508.0 Hoods.
508.1 Where Required. Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces com-
parable amounts of steam, smoke, grease, or heat 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. A Type II hood shall be permitted to be installed at or above dishwashers and cooking appliances that produce heat or do not produce grease or smoke in a food-processing establishment.

Exceptions:
(1) – (2) (remaining text unchanged)
(3) Dishwashing machines connected to a Type II duct system and exhausted directly to the outdoors.
(4) Dishwashing machines with a self-contained condensing system listed in accordance with UL 921 and installed in a facility space where the HVAC system has been engineered to handle 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.

COMMITTEE STATEMENT:
The text “A Type II hood shall be permitted to be installed at or above dishwashers and cooking appliances that produce heat or do not produce grease or smoke in a food-processing establishment” is being deleted in favor of the language approved for Item #140. Furthermore, the proposed modification to exception 4 will clarify that dishwashing machines installed in a space where the HVAC system has been engineered to accommodate for the emitted latent and sensible heat loads must be approved by the Authority Having Jurisdiction. Lastly, interlock provisions are being added as they are necessary for the health and safety of the public.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
ADLER: I agree with the TC action, which was to accept as modified by providing an interlock device, which will keep the machine shut until the steam is dissipated.
CARROLL: This equipment has been listed to the full requirements of UL 921. To my knowledge, UL has never listed a piece of equipment solely to the supplement of a standard. The supplement of UL 921 was developed to provide designers, contractors and AHJs with labeled confirmation of the latent heat and moisture content given off by the equipment. In this case, the values confirm the extremely low amounts given off.

The additional statement regarding the switch is confusing. I am not sure what the submitter's are referring to. To my knowledge there is no switch on a dishwasher that would defeat a building HVAC system. I agree with the TC action to accept with the modification of providing an interlock device to prevent premature opening of the equipment.

RIBBS: After reviewing the comment submitted by Ms. Carroll stating the equipment is listed to the full UL 921. The amended Public Comment 1 which provides for an interlocking switch to prevent premature opening of equipment, and the inclusion of language regarding the role of the AHJ I am changing my vote to “affirmative.”

EXPLANATION OF NEGATIVE:
BERGER: The equipment is not listed to UL 921 but only approved to a supplement of UL 921. The approved equipment comes with an on/off switch which will allow the operator to defeat the original accepted design of the building HVAC system.
MANN: The equipment is not listed to UL 921 but only approved to a supplement of UL 921. The approved equipment comes with an on/off switch which will allow the operator to, by turning off the switch, defeat the original accepted design of a buildings HVAC system.

PUBLIC COMMENT 2:
SUBMITTER: Charlie Souhrada, North American Association of Food Equipment Manufacturers (NAFEM)
RECOMMENDATION: Request to accept the code change proposal as submitted by this public comment.

SUBSTANTIATION: According to the current UMC provisions, all dishwashers must have a hood. However, installing a hood above a machine that does not emit excessive heat or steam wastes energy and money. The current UMC language does not allow for the needs of individual location that cannot install a hood due to physical constraints such as interior placement within larger facilities or in multistory buildings. The current language also does not allow for innovative functional solutions or technological advancement.

Changing the language of the code to a performance criteria will allow for energy efficient systems that meet the same criteria for operator comfort, food safety, and sanitation. The energy capture and heat load reducing systems that are available from several manufacturers have been proven to effectively reduce the heat load from dishwashers to levels which can be accounted for within the design of the HVAC system. Failing to allow the use of these existing technologies, negatively impacts environmental conservation efforts and penalizes manufacturers, their customers, and the general public by preventing them from realizing the benefits of new technologies and other future efficiencies.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT: The public comment is being rejected based on the action taken on Public Comment 1.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
ADLER: I agree with the TC action which was to reject Public Comment 2 in favor of Public Comment 1. I agree with the TC action, which was to accept as modified by providing an interlock device, which will keep the machine shut until the steam is dissipated.

CARROLL: This equipment has been listed to the full requirements of UL 921. To my knowledge, UL has never listed a piece of equipment solely to the supplement of a standard. The supplement of UL 921 was developed to provide designers, contractors and AHJs with labeled confirmation of the latent heat and moisture content given off by the equipment. In this case, the values confirm the extremely low amounts given off.

The additional statement regarding the switch is confusing. I am not sure what the submitter is referring to. To my knowledge, there is no switch on a dishwasher that would defeat a building HVAC system. I agree with the TC action to reject this and accept Public Comment 1 with modifications.

EXPLANATION OF NEGATIVE:
RAMOCIOTTI: The equipment is not listed to UL 921, but only approved to a supplement of UL 921. The approved equipment comes with an on/off switch which will allow the operator by turning off the switch to defeat the original accepted design of the building HVAC system.

PUBLIC COMMENT 3:
SUBMITTER: Thomas Johnson, JDP, Inc.

RECOMMENDATION: Request to accept the code change proposal as submitted by this public comment.
SUBSTANTIATION:
The primary risk factor mitigated by Type II systems is elevated humidity. High humidity for extended periods of time presents an environmental condition that is ideal for the propagation of various species of mold that have in turn been tied to sick building syndrome (SBS). Type II systems exist to protect public health. In general, sensible heat is not a hazard, which is evident by the fact that the code requires buildings to be heated to a minimum acceptable temperature given by its design climate, occupancy, and construction. But, have you noticed that codes don’t mandate for building air conditioning/cooling? "Excess" sensible heat is largely a misnomer given the vast majority of the population in the U.S. reside in zones that spend more energy dollars on heating than on cooling. Space heaters and temporary heat is allowed in buildings, yet they are not required to have exhaust hoods. The sensible heat energy that is not used in a food service process is left in the space to off set-point comfort on a HVAC systems thermostat. In a similar manner, odors are neither quantified nor codified. Rather, they are the subject of litigation for nuisance when 5 or more trained and certified "noses" detect unacceptable odor concentrations and file affidavits on behalf of a complainant.

Clearly, the primary rationale for requiring a Type II hood is to capture and control emissions of latent heat (moisture) which would otherwise raise relative humidity above 60% at some point or points in the space for certain lengths of time, sufficient so as to support the growth of aspergillus niger and other species of mold where acute exposures are known to cause allergic response by certain sensitive building occupants.

For these reasons, when a latent heat emitting process is mitigated by a performance certified UL 921 intervention, it is proven beyond a reasonable doubt to provide sufficient control of latent heat emissions so as to prevent elevated relative humidity in the in door environment. To mandate a Type II hood system above such a listed system is arbitrary and superfluous.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT: The public comment is being rejected based on the action taken on Public Comment 1.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
ADLER: I agree with the rejection of Public Comment 3 in favor of Public Comment 1. I agree with the TC action, which was to accept as modified by providing an interlock device, which will keep the machine shut until the steam is dissipated.

EXPLANATION OF NEGATIVE:
RAMOCIOTTI: The equipment is not listed to UL 921, but only approved to a supplement of UL 921. The approved equipment comes with an on/off switch that will allow the operator by turning off the switch to defeat the original accepted design of the building HVAC system.

PUBLIC COMMENT 4:
SUBMITTER: James Bittner, Insinger Machine

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
508.1 Where Required. Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, grease, or heat 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) – (2) (remaining text unchanged)
(3) Appliances with a separate exhaust duct system directly connected to the appliance and ducted to the outside.
(4) Appliances that include a vapor recovery removal system listed in accordance with UL 921 a recognized product safety certification organization, and installed in a facility that is directly connected to the appliance, and is installed in a space where the HVAC system is capable of accommodating the latent and sensible heat loads from such appliances.
(5) Undercounter commercial dishwashers that are in accordance with the energy star program requirements for commercial dishwashers where the HVAC system is capable of accommodating the latent and sensible heat loads from such appliances.

SUBSTANTIATION:
1. In note 3, the current language is vague and requires clarification to prevent the duct from just ending into another space.
2. In note 4, at this point in time, UL 921 does not include all potential means for certifying vapor removal products. UL has various standards that could and will cover the safety aspect of different products that could potentially be used to remove vapor from a commercial dishwasher.
3. In note 5, commercial undercounter dishwashers that produce relative small amounts of steam should be exempt from the hood requirement.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT: The public comment is being rejected based on the action taken on Public Comment 1.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
RAMOCIOTTI: The equipment is not listed to UL 921, but only approved to a supplement of UL 921. The approved equipment comes with an on/off switch which will allow the operator by turning off the switch to defeat the original accepted design of the building HVAC system.
SUBMITTER:  Jayendra S. Parikh  
Compliance Solutions International Inc.

RECOMMENDATION:
Revise text as follows:

**509.2.3.2 Accessibility.** Filters shall be easily accessible and removable for cleaning removal. [NFPA 96:6.2.3.4]

SUBSTANTIATION:
This change clarifies the requirement that all grease filters need to be accessible for removal no matter what the reason whether cleaning or replacement.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed revision was rejected as the language in NFPA 96 is preferred.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

**509.2.3.2 Accessibility.** Grease filters shall be easily accessible for removal. [NFPA 96:6.2.3.5]

SUBSTANTIATION:
Note: The reason the Technical Committee rejected this proposal was that they preferred the language from NFPA 96. However, NFPA 96-2014 was revised to be consistent with the original submittal. Therefore, Section 509.2.3.2 should be modified to correlate with NFPA 96-2014 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 21      NOT RETURNED: 1 Garza
510.5 Other Grease Ducts. Other grease ducts shall comply with the requirements of this Section 510.5.1 through Section 510.5.2.3. [NFPA 96:7.5]

510.2.1 Installation. Listed grease ducts shall be installed in accordance with the terms of their listings and manufacturer’s installation instructions. [NFPA 96:7.1.7]

510.7.3 Listed. For listed grease ducts, see Section 510.4.

SUBSTANTIATION:
1. Section 510.5 is being revised by making reference to Section 510.5.1 through Section 510.5.2.3 as opposed to indicating “this section” for clarity.
2. Section 510.2.1 and Section 510.7.3 are being deleted to avoid using redundant language; listed grease ducts are already addressed in Section 510.4. For informational purposes only, Section 510.4 is shown as follows: 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]

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
Section 510.2.1 and Section 510.7.3 should not be deleted as they are required for the enforcement of grease duct installations.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

510.7.3 Listed. For listed grease ducts, see Section 510.4.

SUBSTANTIATION:
The revision to Section 510.5 is necessary as indicating “this section” is not clear to the end user to what “this section” includes. Making reference to Section 510.5.1 through Section 510.5.2.3 is necessary for ease of use of the code and to comply with the IAPMO Manual of Style. Furthermore, Section 510.2.1 is not necessary as it is already addressed in Section 510.4. For informational purposes only, Section 510.4 is shown as follows: 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].
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
Section 510.2.1 should not be deleted as they are necessary for the enforcement and installation of grease ducts.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
508.0 Hoods.

508.1 Where Required. **Type I** hoods shall be installed at or above commercial-type deep-fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces comparable amounts of steam, smoke, or grease, or heat 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. **Type II** hoods shall be installed above equipment and dishwashers that generate steam, heat, and products of combustion, and where grease or smoke is not present.

**Exceptions:**

1. Cooking appliance that has been listed in accordance with EPA 202 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.
3. The additional heat and moisture loads generated by unhooded electric equipment and dishwashers are included in the sensible and latent cooling load calculations to determine the required capacity of the HVAC system.

508.4.1 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.

508.4.1.1 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 of the following formulas, in accordance with Section 508.4.1.2 through Section 508.4.1.6. The exhaust quantity shall be the net exhaust from the hood determined in accordance with Equation 508.4.1.1. 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.

\[
E_{NET} = E_{HOOD} - MA_{ID} \quad \text{(Equation 508.4.1.1)}
\]

Where:

- \(E_{NET}\) = net hood exhaust,
- \(E_{HOOD}\) = total hood exhaust,
- \(MA_{ID}\) = makeup air, internal discharge.

\(A\) = the horizontal surface area of the hood, in square feet (m²).

\(P\) = that part of the perimeter of the hood that is open, in feet (mm).

\(D\) = distance in feet (mm) between the lower lip of the hood and the cooking surface.

\(Q\) = quantity of air, in cubic feet per minute (m³/s).

Where cooking equipment is installed back to back and is covered by a common island-type hood, the airflow required shall be calculated using the formula for three sides exposed. **Type II** hood airflow requirements shall be in accordance with the requirements for low-temperature appliance hoods.
508.4.1.2 Solid-Fuel Cooking Equipment. The airflow for solid-fuel cooking equipment, grease burning charbroilers, and undefined equipment shall be not less than the following:

Number of Exposed Sides Formula
4 (island or central hood)   \( Q = 300A \)
3 or less               \( Q = 200A \)
Alternate formula       \( Q = 100PD \)

508.4.1.2 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 508.4.1.2.

<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 m\(^3\)/s, 1 foot = 25.4 mm

508.4.1.3 High Temperature Appliances. Type I hoods where the cooking equipment includes high temperature appliances such as deep fat fryers:

Number of Exposed Sides Formula
4 (island or central hood)   \( Q = 150A \)
3 or less               \( Q = 100A \)
Alternate formula       \( Q = 100PD \)

508.4.1.3 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 508.4.1.3.

<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 m\(^3\)/s, 1 foot = 25.4 mm

508.4.1.4 Medium Temperature Appliances. Type I hoods where the cooking equipment includes medium temperature appliances such as rotisseries, grills, and ranges:

Number of Exposed Sides Formula
4 (island or central hood)   \( Q = 100A \)
3 or less               \( Q = 75A \)
Alternate formula       \( Q = 50PD \)
508.4.1.4 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 508.4.1.4.

<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 = 25.4 mm

508.4.1.5 Medium to Low Temperature Appliances. Type I hoods where the cooking equipment includes low-temperature appliances such as low-temperature ranges, roasters, roasting ovens, pastry ovens, and equipment approved for use under a Type II hood, such as pizza ovens:

Number of Exposed Sides Formula

4 (island or central hood) \( Q = 75A \)

3 or less \( Q = 50A \)

Alternate formula \( Q = 50PD \)

Exception: Listed exhaust hoods are to be installed in accordance with the terms of their listings and the manufacturer’s installation instructions.

508.4.1.5 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 cooks, electric and gas compartment steamers (both pressure and atmospheric), electric and gas cheesemelters, electric and gas tilting skillets (braising pans) electric and gas rotisseries, and electric and gas salamanders shall be in accordance with Table 508.4.1.5.

<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>250</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 = 25.4 mm

508.4.1.6 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.

SUBSTANTIATION:

Commercial kitchen hood exhaust airflow rates are mainly determined by the effluent and thermal plume generated by the cooking process. Recent ASHRAE research reports (e.g., RP-1202 Effect of Appliance Diversity and Position on Commercial Kitchen Hood Performance, RP-1362 Revised Heat Gain and Capture and Containment Exhaust Rates from Typical Commercial Cooking Appliances, RP-1480 Island Hood Energy Consumption and Energy Consumption Strategies, etc.) has found that other factors affect hood performance. They include the introduction of
makeup air, appliance positioning under the hood, and the style and size of hood. An increased depth of a hood (front-to-back) has a very beneficial effect on hood performance. If the appliance line is positioned against the wall of a 4 foot deep or 5 foot deep wall-mounted canopy hood, research has found that the capture and containment rate of the 5 foot deep hood will be approximately 40% less than the 4 foot deep canopy hood. The extra foot of hood front overhang allows the thermal plume to be exhausted more efficiently by allowing it to recirculate and not escape from the front of the hood. In result, the threshold of capture and containment is less than that for larger hoods with more front overhang. The current formulas in Section 508.4.1.1 do not allow for the benefit of increased hood depth. In fact, it penalizes the best-practice design by requiring more airflow for a larger hood by increasing the airflow requirement through \( Q = CA \) or \( Q = PD \) formulas. The proposed changes calculate exhaust airflow rate based on cubic foot per minute per linear foot of hood basis and do not penalize larger depths of hoods. It encourages greater hood front overhang that enhances hood performance. Furthermore, the proposal also adds a reference to Type II hoods which is consistent with ASHRAE 154. These airflow calculations have existed in other model codes and design guides for over a decade. The Exception in current Section 508.4.1.5 (Medium to Low Temperature Appliances) is being relocated to Section 508.4.1.1 since it applies to the capacity of all hoods.

**COMMITTEE ACTION:** Accept as Amended by the TC

Amend proposal as follows:

508.0 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 produces 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. Type II hoods shall be installed above equipment and dishwashers that generate steam, heat, and products of combustion, and where grease or smoke is not present.

Exceptions:

1. Cooking appliance that has been listed in accordance with EPA 202 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.

3. The additional heat and moisture loads generated by unhooded electric equipment and dishwashers are included in the sensible and latent cooling load calculations to determine the required capacity of the HVAC system.

**COMMITTEE STATEMENT:**

In Section 508.1, Exception 3 was deleted based on the concern that hoods would not be required to be installed for commercial dishwashers.

**Note:** Item # 140 failed to achieve the necessary 2⁄3 affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:

SUBMITTER: Rich Swierczyna, Organization Food Service Technology Center

RECOMMENDATION:

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

508.4.1 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.
SUBSTANTIATION:
The submitter agrees with the Technical Committee and the membership regarding the necessity of the phrase “terms of their listing” with respect to life/safety, enforcement, and exception issues. The phrase “terms of their listing” should be part of the proposal and is being put back into Section 508.4.1 (exception).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2 (Assembly Action):
SUBMITTER: Brent Hipsher, City of Palo Alto

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
In Section 508.4.1, the manufacturer’s installation instructions and listing standards are not always the same. Therefore, both requirements are needed for necessary life/safety installations. Having both aids in the inspection and enforcement.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Jayendra S. Parikh
Compliance Solutions International Inc.

RECOMMENDATION:
Revise text as follows:

514.2 Inspection. 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 trained, qualified, and certified person(s) or company acceptable to the Authority Having Jurisdiction not less than every 6 months. [NFPA 96:11.2.1]

SUBSTANTIATION:
1. Maintenance/inspection of the systems and hoods mentioned in this section is conducted by a person, not a company.
2. The definition of “trained” (in Section 222.0) mentions a “person” and not a “company.”
3. Only the person, and not company, is mentioned in this requirement in Section 11.2.1 in NFPA 96.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The term “or company” is required as some jurisdictions may require both the person and the company to be qualified.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

SUBSTANTIATION:
The Technical Committee reason for rejecting the proposal was that “only the person, and not the company, is mentioned in this requirement in Section 11.2.1 of NFPA 96.” However, Section 11.2.1 of NFPA 96 has been revised by removing the term “or company.” Therefore, Section 514.2 should be modified to correlate with NFPA 96-2014 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Jeffrey Hutcher  
City of Oakland

RECOMMENDATION:  
Revise text as follows:

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) - (9) (remaining text unchanged)

(10) Provisions shall be provided for latent heat and excessive moisture acceptable to the Authority Having Jurisdiction.

SUBSTANTIATION:
This section only refers to test under standard UL 710B. UL 710B only tests to EPA 202, which deals with the removal of pollutants to an acceptable level. It does not deal with the latent heat or moisture generated by recirculating equipment. Other sections for commercial hoods over cooking equipment take these items seriously for a worker’s environment, comfort, and indoor air quality.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed language is vague and uses nonmandatory language such as “acceptable.”

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT (Assembly Action):
SUBMITTER: Jeffrey Hutcher, City of Oakland

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

SUBSTANTIATION:
The proposed language should be accepted based on the original substantiation. Furthermore, if excess heat and moisture are issues for dishwashers, the same logic should apply to recirculation hoods tested for pollutants only.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The proposed language is too vague for both the designer and the code official to judge acceptance.
518.0 Down Draft Appliances.

518.1 General. The ventilation system for a down draft appliance shall be capable of capturing and containing the effluent discharge from the appliances it serves. [NFPA 96:15.1.2]

518.2 Fire-Extinguishing Equipment. Fire-extinguishing equipment for a down draft appliance ventilation system shall comply with the following:

(1) Cooking surface, duct, and plenum protection shall be provided.

(2) Not less than one fusible link or heat detector shall be installed within the exhaust duct opening in accordance with the manufacturer’s listing.

(3) A fusible link or heat detector shall be installed above the protected cooking appliance and in accordance with the extinguishing system manufacturer’s listing.

(4) A manual activation device shall be installed as part of the 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]

518.2.1 Integral Fire-Extinguishing System. A listed down draft 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 518.2. [NFPA 96:15.2.1]

518.2.2 Interlocks. The down draft 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]

518.3 Airflow Switch or Transducer. An airflow switch or transducer shall be installed after the last filter component to ensure that a minimum airflow is maintained. [NFPA 96:15.3.1]

518.3.1 Interlocks. The airflow switch or transducer shall open the interlock circuit where the airflow is less than 25 percent the system’s normal operating flow or less than 10 percent its listed minimum rating, whichever is less. [NFPA 96:15.3.2]

518.3.2 Manual Reset. The airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:15.3.3]

518.4 Surface Materials. Surfaces located directly above the cooking appliance shall be of noncombustible or limited-combustible materials. [NFPA 96:15.4]

SUBSTANTIATION:

Down draft appliances are being used more and more and the code currently does not address provisions for safe installations for such appliances. Section 518.0 addresses such appliances as hood-less griddle type cooking appliances which are sometimes referred to as Hibachi Tables. Typically the portion of food prepared is small and are prepared in front of the customers directly at their table. Hibachi tables have built-in downdraft exhaust systems with two fans, one to push the smoke and one to draw air across the table. The cooking vapors are then captured and conveyed to a grease duct that is attached to the bottom of the table. The proposed language is a direct extraction from NFPA 96-2011.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:

SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.
RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.

518.1 General. A down draft 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 clearance requirements in accordance with Section 507.3.
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 is 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]

518.2 Ventilation System. The ventilation system for a down draft appliance shall be capable of capturing and containing the effluent discharge from the appliance it serves. [NFPA 96:15.1.2]

(renumber remaining sections)

SUBSTANTIATION:
Section 518.1 is being modified to correlate with NFPA 96-2014 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). Furthermore, such language is necessary to assist the end user in determining what sections of the code apply to down draft appliances.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 359 for "manufactured homes" resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

D 1.2 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 in a work-like manner. For the installation of liquefied petroleum gas (LPG) storage systems, the applicable provisions of NFPA 58 shall be followed. [NFPA 501A:4.1.2].

D 2.1.2 Requirements. The open-ended gastight conduit shall comply with the following:

1 – (3) (remaining text unchanged)

4. Where the conduit terminates within a M/H, accessory building, or structure, it shall be readily 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]
D 3.1 General. Each M/H site shall have a listed gas shutoff valve installed upstream of the M/H 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 finished grade. A gas shutoff valve shall not be located under a M/H. The outlet shall be equipped with a cap or plug to prevent discharge of gas where the M/H site outlet is not connected to a M/H.

Exception: Gas shutoff valves 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 5.0 Multiple Manufactured Home Site Fuel Distribution and Supply Systems. [NFPA 501A: 4.1, 4.3.11, 4.4, and 4.4.5]

D 6.0 Cathodic Protection Requirements.

D 6.1 General. (remaining text unchanged)

D 7.0 Manufactured Home Community LPG Supply Systems.

D 7.1 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 supply systems and the storage and handling of LPG shall be in accordance with NFPA 58 (see Section D 13.0). [NFPA 501A:4.3.2]

D 8.0 Required Gas Supply.

D 8.1 General. The minimum hourly volume of gas required at each M/H site outlet or a section of the M/H community gas piping system shall be calculated as shown in Table D 8.1. [NFPA 501A:4.3.4.1]

TABLE D 8.1
DEMAND FACTORS FOR USE IN CALCULATING GAS PIPING SYSTEMS IN M/H COMMUNITIES* [NFPA 501A: TABLE 4.3.4.1, 4.3.4.2]

(remaining table text unchanged)

D 9.0 Gas Pipe Sizing and Pressure.

D 9.1 Size. (remaining text unchanged)

D 9.2 Pressure. (remaining text unchanged)

D 10.0 Gas Piping Materials.

D 10.1 Metal. (remaining text unchanged)

D 10.2 Protection Coatings for Metal Gas Piping. (remaining text unchanged)

D 10.3 Plastic. (remaining text unchanged)

D 11.0 Gas Piping Installations.

D 11.1 Minimum Burial Below Ground Level and Clearances. (remaining text unchanged)

D 11.2 Metallic Gas Piping. (remaining text unchanged)

D 11.2.1 Cathodic Protection. (remaining text unchanged)

D 11.2.2 Underground Metallic Systems. (remaining text unchanged)

D 11.3 Plastic Gas Piping. (remaining text unchanged)

D 11.4 Gas Piping System Shutoff Valve. An accessible and identifiable shutoff valve controlling the flow of gas to the entire M/H community gas piping system shall be installed in a location approved by the Authority Having Jurisdiction and near the point of connection to the service piping or to the supply connection of an LPG container. [NFPA 501A:4.3.7.4]

D 12.0 Liquefied Petroleum Gas Appliances.
D 12.1 D 11.1 General. (remaining text unchanged)

D 13.0 D 12.0 Oil Supply.
D 13.1 D 12.1 General. (remaining text unchanged)
D 13.2 D 12.2 Minimum Oil Supply Tank Size. (remaining text unchanged)
D 13.3 D 12.3 Oil Supply Connections. Oil supply connections at M/H sites, where provided from a centralized oil distribution system, shall be located and arranged to permit attachment in a work-like manner to a M/H utilizing the stand. [NFPA 501A:4.3.11.1]

(remaining text unchanged)

D 14.0 D 13.0 Fuel Supply Systems Installation.
D 14.1 D 13.1 Flexible Gas Connector. Each gas supply connector shall be listed for outside M/H use, shall be not more than 6 feet (1829 mm) in length, and shall have a capacity rating adequate to supply the connected load.

(remaining text unchanged)

D 14.2 D 13.2 Use of Approved Pipe and Fittings of Extension. (remaining text unchanged)
D 14.3 D 13.3 Mechanical Protection. (remaining text unchanged)
D 14.4 D 13.4 Special Rules on Atmospherically Controlled Regulators. (remaining text unchanged)
D 14.5 D 13.5 Fuel Gas Piping Test. (remaining text unchanged)
D 14.5.1 D 13.5.1 Procedures. The fuel gas piping test shall consist of air pressure at or 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 gas supply connector shall be installed, and the connections shall be tested with soapy water or bubble solution. [NFPA 501A:4.4.5.1]

D 14.5.2 D 13.5.2 Warning. (remaining text unchanged)
D 14.5.3 D 13.5.3 Vents. (remaining text unchanged)
D 14.6 D 13.6 Oil Tanks. Not more than one 660 gallon (2498 L) tank or two tanks with aggregate capacity of 660 gallons (2498 L) or less shall be connected to one oil-burning appliance. Two supply tanks, where used, shall be cross-connected and provided with a single fill and single vent in accordance with NFPA 31, and shall be on a common slab and rigidly secured one to the other. 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]

D 14.6.1 D 13.6.1 Installation. (remaining text unchanged)
D 14.6.2 D 13.6.2 Capacity. (remaining text unchanged)
D 14.6.3 D 13.6.3 Location. Tanks, as described in Section D 14.6 D 13.6 and Section D 14.6.2 D 13.6.2, 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 14.6.4 D 13.6.4 Vent. Tanks with a capacity not larger than 660 gallons (2498 L) shall be equipped with an open vent not smaller than a 1½ inch (40 mm) iron pipe size; tanks with a 500 gallon (1892 L) or less capacity shall have a vent of 1½ inch (32 mm) iron pipe size. [NFPA 501A:4.4.6.4]
D 14.6.5 D 13.6.5 Liquid Level. (remaining text unchanged)
D 14.6.6 D 13.6.6 Fill Opening. (remaining text unchanged)

D 15.0 D 14.0 Manufactured Home Accessory Building Fuel Supply Systems.
D 16.1 D 14.1 General. (remaining text unchanged)
Community Building Fuel Supply Systems in Manufactured Home Communities.

Fuel Gas Piping and Equipment Installations. Fuel gas piping and equipment installed within a permanent building in a M/H 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]

Oil Supply Systems in M/H Communities. Oil burning equipment and installation within a M/H 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 NFPA 31. [NFPA 501A:4.6.2]

Fuel gas piping and equipment installed within a permanent building in a M/H 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]

Oil Supply Systems in M/H Communities. Oil burning equipment and installation within a M/H 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 NFPA 31. [NFPA 501A:4.6.2]

Oil-Burning Equipment and Installation. Oil burning equipment and installation within a building constructed in a M/H 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]

Inspections and Tests. (remaining text unchanged)

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revisions to Appendix D of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as submitted” Item # 359 in regards to updating the manufactured home provisions in accordance with NFPA 501A.

The substantiation provided by the UPC for accepting the public comment Item # 359 as submitted is as follows:
1. “Sections within Appendix E of the UPC are being revised to correlate with NFPA 501A-2013 (latest version) in accordance with IAPMO's Regulations Governing Committee Projects (Extract Guidelines).
2. Section E 27.0 (Multiple Manufactured Home Site Fuel Distribution and Supply Systems) should be deleted as it does not contain any provisions that can be applied or enforced.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC in regards to updating the manufactured home provisions in accordance with NFPA 501A.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 299 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

<table>
<thead>
<tr>
<th>TABLE 803.1.2(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTERIOR MASONRY CHIMNEY</td>
</tr>
<tr>
<td>[NFPA 54: TABLE 13.1(f)]^{22}</td>
</tr>
</tbody>
</table>

(remaining text unchanged)

Notes:
1. See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2. NA: Not applicable.
TABLE 803.1.2(13)
EXTERIOR MASONRY CHIMNEY
[NFPA 54: TABLE 13.2(g)]¹²

(portions of table not shown remain unchanged)

Notes:
¹ See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
² NA: Not applicable.

TABLE 803.1.2(15)
EXTERIOR MASONRY CHIMNEY
[NFPA 54: TABLE 13.2(i)]¹²

(portions of table not shown remain unchanged)

Notes:
¹ See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
² NA: Not applicable.

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]

F 2.4 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 Example 5(b) are to be common-vented 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 this exterior masonry chimney need to be relined? Where so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended? [See Table F 2.3 and Figure 803.1.2(6)]

(remaining text unchanged)

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revision to Table 803.1.2(6), Table 803.1.2(13), Table 803.1.2(15), and Section F 2.4 will correlate with the UPC in regards to the winter design temperature. Furthermore, it will correlate with NFPA 54-2012.

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC.

PUBLIC COMMENT 2:
SUBMITTER: Jayendra S. Parikh, Compliance Solutions International Inc.

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

510.1.4 Down Draft Appliances. Exhaust ducts used in down draft appliance ventilation systems shall be permitted to include an upturn in the duct provided the trapped area contains a low point drain to an approved grease reservoir not exceeding 1 gallon (4 L) in capacity, and the entire length of the duct is easily accessible. [NFPA 96:7.1.4.6]
(renumber remaining sections)

SUBSTANTIATION:
Provisions for down draft appliances have been added to the UMC. However, it is lacking a provision for the requirement for a grease reservoir. Such installation is required as it is only applicable to exhaust ducts used with down draft appliances. Section 510.1.4 will be consistent with NFPA 96-2014.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed language does not include all the provisions that are necessary to completely correlate with NFPA 96. Furthermore, it lacks fire safety provisions that are necessary for the safe installation of grease reservoirs.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 83)

RECOMMENDATION:  
Revise text as follows:

602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling systems shall be conducted through duct systems constructed of metal in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible. 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 tightly sealed.

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.

(remaining text unchanged)

607.15 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.

SUBSTANTIATION:  
Language pertaining to corridors in Section 602.1 is being relocated to new Section 607.15 for ease of use of the code.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:  
SUBMITTER: Steven Guttmann, Guttmann & Blaevoet Consulting Engineers

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

607.15 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.

Exceptions:

1. Incidental air movement between corridors of fire-resistive construction and adjacent spaces shall be permitted where adjacent spaces are required to be maintained at a negative or positive pressure relationship to the corridor for odor control, contaminant control, or other needs as approved by the Authority Having Jurisdiction. In such cases, corridors shall be directly supplied with makeup air at a rate that exceeds the net rate of transfer air. For air movement from pressurized rooms (other than toilet rooms, bathrooms, and janitor closets), the corridor shall not be the primary source of supply air to or return air from rooms over 50 square feet (4.65 m²).

2. For toilet rooms, bathrooms, and janitor closets, transfer air from the corridor shall be permitted to be the source of makeup air for exhaust systems in such rooms that open directly onto corridors of fire-resistive construction, regardless of room size. In such cases, corridors shall be directly supplied with makeup air at a rate that exceeds the net rate of transfer air.

3. Within a dwelling unit, corridors of fire-resistive construction shall be permitted to be used for conveying return air.
SUBSTANTIATION:
The proposed change will add exceptions to allow the use of transfer air from rated corridors in certain cases. This is necessary to accommodate the need to have rooms that are pressurized in relation to rated corridors for control of odors and contaminants. It also allows for the use of corridors in single family dwelling units to be used for return air which is an industry standard practice.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

602.8 Corridors. Corridors shall not be used to convey air to or from rooms where the corridor is required to be of fire-resistant construction in accordance with the building code.

Exceptions:
(1) Incidental air movement between corridors of fire-resistive construction and adjacent spaces shall be permitted where adjacent spaces are required to be maintained at a negative or positive pressure relationship to the corridor for odor control, contaminant control, or other needs as approved by the Authority Having Jurisdiction. In such cases, corridors shall be directly supplied with makeup air at a rate that exceeds the net rate of transfer air. For air movement from pressurized rooms (other than toilet rooms, bathrooms, and janitor closets), the corridor shall not be the primary source of supply air to or return air from rooms over 50 square feet (4.65 m²).
(2) For toilet rooms, bathrooms, and janitor closets, transfer air from the corridor shall be permitted to be the source of makeup air for exhaust systems in such rooms that open directly onto corridors of fire-resistive construction, regardless of room size. In such cases, corridors shall be directly supplied with makeup air at a rate that exceeds the net rate of transfer air.
(3) Within a dwelling unit, corridors of fire-resistive construction shall be permitted to be used for conveying return air.

COMMITTEE STATEMENT:
The proposed exceptions have not had public review as it introduces a new concept which was not included in a related proposal as published in the ROP. However, the Technical Committee agrees that the corridors provisions should be addressed in Section 602.8 as it is a general material requirement.

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
RECOMMENDATION:
Revise text as follows:

602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling systems shall be conducted through duct systems constructed of metal shall comply in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible. 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 tightly sealed.

602.5 Metal. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible or duct systems in accordance with UL 181.

SUBSTANTIATION:
1. In Section 602.1, the text “Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible” is being deleted since such language was only valid in the 2009 edition of the code. For informational purposes only, Section 602.1 in the 2009 edition read as follows: Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with UMC Standard No. 6-2 or the reference HVAC duct construction Standard in Chapter 17. However, reference to UMC Standard No. 6-2 was removed during the 2012 cycle, but the language pertaining to that reference should have been removed as well. The reference to UMC Standard No. 6-2 was replaced with a reference to SMACNA. SMACNA does not only address rectangular ducts exceeding 2 inches (51 mm) w.g, but addresses round ducts as well and in various sizes. Therefore, the entire sentence should be removed to avoid any confusion.

2. Section 602.5 is being deleted since the language is redundant to language found in Section 602.1 and Section 602.3. Section 602.1 indicates that metal ducts shall comply with SMACNA HVAC Duct Construction Standard. As far as the reference to UL 181 is concerned, it is a standard for factory-made air ducts which includes flexible air ducts; factory-made air ducts are already addressed in Section 602.3.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling duct systems constructed of metal shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible or UL 181. 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 tightly sealed.

602.5 Metal. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible or duct systems in accordance with UL 181.

COMMITTEE STATEMENT:
Reference to UL 181 was added in Section 602.1 as it is an applicable standard for the construction of factory-made air ducts. Section 602.5 should not be deleted as it is required for the construction of metal ducts, plenums, or fittings.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Dan Buuck, National Association of Home Builders (NAHB)

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

602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling duct systems constructed of metal shall comply with SMACNA HVAC Duct Construction Standards—Metal and Flexible or UL 181 shall comply with Section 602.2 through Section 602.8. 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 tightly sealed.

602.8 Concrete, Clay or Ceramics. 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 tightly sealed.

SUBSTANTIATION:
The reference to UL 181 in Section 602.1 is not applicable as UL 181 is specifically for factory-made air ducts, which is already reference in Section 602.3 (Metal Ducts) and Section 602.6 (Factory-Made Air Ducts). Furthermore, the reference to the SMACNA standard is being removed as it is already addressed in Section 602.3 (Metal Ducts). Therefore, reference to Section 602.2 through Section 602.8 must be added to avoid the use of redundant language and ambiguity.

The text “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 tightly sealed” is being relocated from Section 602.1 to Section 602.8 for ease of use of the code.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment creates confusion and it removes provisions that are necessary for the enforcement of the section.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT: The comment is technically correct. The TC did not provide a technical reason for rejecting the comment. The comment clarifies the intent and does not create confusion.

TAYLOR: The proposal is a good one. Ducts, plenums, and fittings shall be permitted to be constructed of concrete, clay, or ceramics. Ducts, plenums, and fittings made of concrete, clay or ceramics cannot meet UL or SMACNA requirements so there is a conflict in which the proposed revision would fix.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 84)

RECOMMENDATION:
Revise text as follows:

602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling systems shall be conducted through duct systems constructed of metal in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible. 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 tightly sealed.

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.

Concealed building spaces or independent construction within buildings shall be permitted to be used as ducts or plenums.

(remaining text unchanged)

607.16 Concealed Building Spaces. Concealed building spaces or independent construction within buildings shall be permitted to be used as ducts or plenums. Such concealed space shall not be part of a required fire-resistance-rated construction, used for supply air, and not serve more than one floor level.

607.16.1 Fireblocking. Concealed spaces used for the movement of air shall be isolated from adjacent concealed spaces with an approved fireblocking.

SUBSTANTIATION:
1. Language pertaining to concealed spaces in Section 602.1 is being relocated to a new Section 607.16 for ease of use of the code.
2. The additional language added to Section 607.16 will allow concealed spaces to be used for return air. Concealed spaces, such as stud and joist cavities, are not considered plenums per the definition of plenum. However, it is common in residential applications that concealed spaces are used as a method of conveying air. Such spaces should be limited to return air since the negative pressures within the return air plenum in comparison with the surrounding spaces will be smaller and decreasing the possibility of spreading smoke to the other spaces. Furthermore, the space shall not be part of a fire-resistance-rated construction or assembly since the fire testing of buildings does not take into account the air movement within the assembly. Lastly, concealed spaces used for air movement shall only serve one floor since connections between floors would act as an enclosure, chase, or chimney where fire and smoke are allowed to spread.
3. Section 607.16.1 will require concealed spaces used for air movement to be installed with an approved fireblocking to limit the spread of fire between the plenum and other spaces.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:

This proposed change has several flaws:

1. Section 602.1 applies to all duct systems while Section 607.0 only applies to underfloor supply plenums in dwelling units. So by deleting the sentence allowing building construction to be used as plenums from Section 602.1 means that they can be used only in underfloor systems in dwelling units.

2. Proposed Section 607.16 does not allow architectural plenums to be used for supply air, yet the entire Section 607.0 addresses underfloor supply air plenums so this section is self-canceling. If the intent was for this limit to apply to other buildings, then it would eliminate raised floor plenums used for data centers and underfloor air distribution systems. No rationale is provided for why these common applications should be eliminated.

3. Proposed Section 607.16 does not allow architectural plenums to be used for more than one floor. It is very common for shafts to be used for return air in multi-story buildings. There is no safety issue because openings would have to be protected with fire and/or smoke dampers.

4. Proposed Section 607.16.1 makes no sense. How can a plenum that is divided by fireblocking act as a plenum? Airflow would be blocked! Perhaps this was intended to apply only to rated walls between spaces, but in that application openings would have to be protected with fire and/or smoke dampers not just fireblocking.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Steven J. Clark, P.E.
Aquatherm

RECOMMENDATION:
Revise text as follows:

602.0 Material.
602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling systems shall be conducted through duct systems constructed of metal in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible. 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 tightly sealed.

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.

Concealed building spaces or independent construction within buildings shall be permitted to be used as ducts or plenums.

(remaining text unchanged)

SUBSTANTIATION:
This paragraph is a major loophole to the intent of this section to provide clear guidelines for the safe and healthy construction of air duct systems. By allowing building cavities to substitute for air ducts, the fire integrity of the building is substantially reduced. An attempt to offset negative safety impact of this loophole is the numerous requirements for building products that are now part of the air system to be tested under the completely inappropriate ASTM E84 test. To meet this requirement building products are often laced with toxic fire retardant chemicals, which can give off deadly gases when burned. Therefore this paragraph dramatically reduces the health and life safety of the building. The justification for this paragraph is that it reduces building costs. Cost savings is not a valid justification for reducing life safety and health, and further is likely not true if the total cost imposed on all other building trades were accounted for.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
This proposal prohibits the use of concealed spaces as ducts including a drop ceiling. The use of return air plenums in large spaces is a common industry practice. In addition, no technical justification was submitted to support the need for this change.

Note: Item # 155 failed to achieve the necessary ⅔ affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
This Item proposes to disallow the use of architectural and structural elements to serve as air plenums. Architectural plenums are extremely common and used in almost every large building. Common applications are:

- Using the ceiling cavity between the hung ceiling and structure above as a return air plenum.
- Using non-rated corridors as return air plenums.
- Using rated shafts as return air risers.
- Using mechanical rooms as return air or mixed air plenums.
- Using raised floors as supply air plenums such as in data centers and underfloor air distribution (UFAD) systems.

The most common of these is the ceiling return air plenum. This is used in almost every building built with a nonflammable structure (e.g. steel, concrete). Why? Because of the following significant advantages over ducted return air:

- Reduces HVAC system costs of about $3 to $5 per square foot, about 10% to 20% of the total HVAC system cost.
- Reduces costs to other trades to accommodate the congestion caused by the added return air ductwork, such as raising the floor-to-floor height or adding additional offsets in plumbing and sprinkler piping.
- Reduced fan energy costs of about 20% to 30% due to the much lower pressure drop of the plenum return system.
- Reduced fan energy in systems with outdoor air economizers due to the ability to use non-powered relief or relief fans in lieu of less efficient return fans, which are generally required when return air is fully ducted (see Comparing Economizer Relief Systems, ASHRAE Journal, September 2000).

The proponent states that there are no net cost savings because of the added cost of plenum rated wiring. That is simply not true as demonstrated by the popularity of return air plenums, but even if it were true, this is a design choice that should be left up to the building design team, not arbitrarily mandated by code.

UFAD systems are popular in “green buildings” because they improve energy efficiency, indoor air quality, and thermal comfort compared to conventional ducted overhead systems. Outlawing UFAD clearly would have a net negative impact on building occupants and owners, counter to the goals of the UMC.

This is a major revision that will have a substantial negative impact on first costs and energy costs yet no reports, studies, or peer reviewed papers were provided by the author to support this radical change. The author of this proposed change works for a manufacturer of plastic piping that cannot be used in air plenums due to its inability to meet smoke generation limits. Thus this proposed change is simply to create an unfair market advantage for his product. Other supporters of this change are sheet metal unions who would benefit by the increased use of sheet metal instead of architectural materials for plenums. These are selfish motives that have nothing to do with the purpose of the UMC which states (Section 101.2): “to provide minimum standards to safeguard life or limb, health, property, and public welfare...” Disallowing architectural plenums does not meet any of these goals. Unless a rationale based on improving safety, health, etc. can be provided, this change should not be made.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 2:
SUBMITTER: Craig Malaer/Christine Tsai/Kristopher Kyle, Webcor Builders
RECOMMENDATION:
Request to **reject** the code change proposal by this public comment.

SUBSTANTIATION:
Disallowing the use of architectural plenum spaces only provides material vendors and installers a means to increase revenue; it is technically baseless.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:   AFFIRMATIVE: 20    NEGATIVE: 1    NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 3:
SUBMITTER: Jeffrey P. Blaevoet, P.E., Guttmann & Blaevoet Consulting Engineers

RECOMMENDATION:
Request to **reject** the code change proposal by this public comment.

SUBSTANTIATION:
The deletion of the text will reduce energy efficiency and increase costs of construction; a very bad idea. Not allowing plenum returns and supply disables the ability to harness structural mass. It removes an important tool for designers to reduce and shift peak loads, and provide flexibility in MEP provisions in buildings. Prescriptive codes stifle innovation. We need more performance based codes. There is no evidence the proposed change will improve IAQ in buildings, or that there are issues with the current practice. This appears to be a case of special interests pushing for something which is not in the public’s interest, and should not be allowed.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:   AFFIRMATIVE: 20    NEGATIVE: 1    NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 4:
SUBMITTER: Allan Daly, P.E., Taylor Engineering LLC

RECOMMENDATION:
Request to **reject** the code change proposal by this public comment.
SUBSTANTIATION:
The language in proposal #155 would effectively eliminate the use of architectural return air plenums. This change will substantially increase construction costs and increase energy use without any demonstrated improvements on building or occupant safety. The author of proposal #155 is acting out of self-interest only (his company sells a product that does not meet requirements for use in return air plenums). I strongly recommend that this proposal be dropped and that architectural return plenums continue to be allowed as they have for many years.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 5:
SUBMITTER: John Murphy, Trane

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Concealed ceiling spaces have been used as return-air plenums for decades, and are very common in larger buildings with centralized air-based systems. A variable-air-volume (VAV) system, which is arguably the most common type of HVAC system used in larger buildings, makes use of a ceiling plenum for return air. This proposal suggests a radical change to current HVAC design and construction practice, which will significantly increase the installation cost and operating cost of VAV systems. Furthermore, the proposal provides no technical substantiation that demonstrates that this practice “dramatically reduces the health and life safety of the building.” No research studies, no peer-reviewed papers, no fire marshal reports, and not even a newspaper article was provided.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 6:
SUBMITTER: Glenn Friedman, P.E., Taylor Engineering LLC

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
The proposed deletion would eliminate the use of architectural return air plenums. There is no technical substantiation provided that this change will improve health and safety. This change will increase construction costs and result in more fan energy usage. I urge this proposal be dropped and that architectural return plenums be allowed without change.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 7:
SUBMITTER: Rob Penrod, P.E., C.E.M., Beutler Corporation

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Architectural plenums are extremely common and used in almost every multi-family HVAC system installed in California in the last 30 years, as well as nearly every large commercial building. The reasons are simple: reduced first cost in construction, reduced energy consumption, and lack of any research indicating significant threat to “life, limb, health, property, and public welfare.”

The lack of impact on health/life safety is particularly significant in this situation. Manufacturers of many different products have worked assiduously to develop products that are “plenum rated.” Furthermore, those products have been subjected to rigorous scrutiny and certified to meet test standards by independent Nationally Recognized Testing Laboratories (NRTLs). Those consensus test standards in turn have been developed under open protocols that employ scientific rigor, peer review, and a regular revision schedule as new information emerges. The standards in place are the result of tens of thousands of hours of review, investigation, challenge, and consideration. Should any party believe that there is a flaw in the standards covering the review of plenum rated products, the appropriate venue for review of those concerns is the Technical Committee in charge of those standards.

Without any guidance from the appropriate standards Technical Committee that there is a problem that needs to be addressed, or in the absence of compelling, peer reviewed research that demonstrates that a given Technical Committee has been informed of a problem and refuse to address it, it is wholly inappropriate for a change such as that suggested to be incorporated into the UMC. The purpose of the UMC is to “provide minimum standards to safeguard life or limb, health, property, and public welfare.”

There is no compelling evidence that the current standards system and NRTL testing system are broken, and particularly in light of the extremely large cost that this would impose on replacement systems, it is inappropriate for the UMC to be modified as suggested. For this reason, I urge that the recommendation of the Committee be upheld, and the proposed revision be rejected.

COMMITTEE ACTION: Accept the public comment as submitted
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 8:
SUBMITTER: Dennis Stanke, Trane

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Most buildings use portions of the structure as air plenums for heating, cooling, and/or ventilation air. The proposed change offers no evidence that the use of these plenums makes buildings less safe. Plenum-rated materials have been in wide use for many years, without safety concerns.

However, prohibiting the use of air plenums increases both the cost and complexity of building mechanical systems. For instance, if the building code were to require that all VAV systems use return air ducts, these systems would require pressure-independent VAV boxes in both the supply and return ducts for each zone, and the operation of these boxes would need to be coordinated to assure proper supply airflow to each zone. In both constant volume and VAV systems, the additional return duct pressure drop would increase building fan energy use.

Reducing the use of VAV systems or under-floor air distribution systems in buildings would increase first costs (both material and installation costs) and operating costs (both fan energy use and maintenance costs) in all buildings, without increasing building safety.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 9:
SUBMITTER: Gurdaver Singh, Guttmann & Blaevoet Consulting Engineers

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
This proposed change is counterintuitive to the industry goals to achieve high efficiency buildings. The use of an architectural plenum can help reduce energy, offset peak load, and construction costs. The use of architectural
Plenums can provide means of using the thermal mass of the building to offset peak demand that benefits the utility companies in their struggle to meet demand. Unless there are safety and or health concerns, the use of architectural plenums should be left to the design team as tool to use to control the energy efficiency, peak load, and costs of the building. The purpose of the UMC is to provide minimum standards to safeguard life or limb, health, property, and public welfare. This proposed change to the code of not allowing architectural plenums does not enhance any of these criteria. Unless a rationale based on improving safety, health, etc. can be provided; this change should not be made.

Committee Action: Accept the public comment as submitted

Total Eligible to Vote: 22

Voting Results: Affirmative: 20 Negative: 1 Not Returned: 1 Garza

Explanation of Negative:
DiAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

Public Comment 10:
Submitter: Reinhard Seidl, Taylor Engineering LLC

Recommendation:
Request to reject the code change proposal by this public comment.

Substantiation:
The exclusion of return air plenums will raise costs without appreciable benefits. No documentation was submitted to the Technical Committee to substantiate the claims that building safety would be improved. There appears to be a conflict of interest as well since the proposal originated from a vendor whose products are cheaper to install once architectural plenums are prohibited, see http://www.aquatherm.com/downloads/bulletins/201205C-AQTTB-Aquatherm-Plenums-2012-IMC-UMC.pdf. Keeping the original language reduces costs and avoids a conflict of interest.

Committee Action: Accept the public comment as submitted

Total Eligible to Vote: 22

Voting Results: Affirmative: 20 Negative: 1 Not Returned: 1 Garza

Explanation of Negative:
DiAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

Public Comment 11:
Submitter: Ted M. Tiffany, Guttmann & Blaevoet Consulting Engineers

Recommendation:
Request to reject the code change proposal by this public comment.
**SUBSTANTIATION:**

If the language is deleted, the proposed change would force higher energy use in nearly every application where added ducts are necessary. The most common restriction would be in return air plenums where very low pressure drops are currently experienced. The proposed change will require fixed ducts which will add significant pressure drops, and increase the overall fan energy. The proposed change will add to greenhouse gas emissions in operations and, likely the total life cycle of the building structures, will increase maintenance, materials, and environmental degradation. The proposed change will also prevent energy saving strategies like underfloor air distribution (UFAD) systems which are common in high performance buildings. The use of displacement air from the supply plenum will not be allowed with the proposed change as it will eliminate an energy conservation strategy that has been proven to save 20% - 30% on HVAC energy.

From the information provided, I see no technical supporting documentation to show that there is an improvement in life-safety by eliminating the sentence proposed. It appears the proponent’s company would benefit greatly by the elimination of this sentence allowing for a possible conflict of interest.

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  
AFFIRMATIVE: 20  
NEGATIVE: 1  
NOT RETURNED: 1 Garza

**EXPLANATION OF NEGATIVE:**  
**DIAS:** I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

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**PUBLIC COMMENT 12:**

**SUBMITTER:** Art Williams, Air Systems

**RECOMMENDATION:**
Request to reject the code change proposal by this public comment.

**SUBSTANTIATION:**

Industry best practices, which have been in place for decades, already allow for the use of concealed spaces as duct systems. There have been no industry wide substantive studies that dispute this practice.

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  
AFFIRMATIVE: 20  
NEGATIVE: 1  
NOT RETURNED: 1 Garza

**EXPLANATION OF NEGATIVE:**  
**DIAS:** I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

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**PUBLIC COMMENT 13:**

**SUBMITTER:** Stephen Poe, Critchfield Mechanical Inc.
RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Item #155 proposes to eliminate architectural return air ceiling plenums and supply air floor plenums for HVAC airflow. This would be detrimental to HVAC system design in large commercial buildings. It will increase building costs since more ductwork will be required. It will congest ceiling spaces due to the added ductwork. It will raise HVAC system operating costs since additional fan horsepower will be required to push air through the added ductwork. This is a terrible change to HVAC system design and architectural ceiling space design. I implore you to not implement this change.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 14:
SUBMITTER: Jeff Stein, P.E., Taylor Engineering LLC

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Proposal #155 is absolutely outrageous. There is nothing wrong with using architectural air plenums as they are used for most buildings. Outlawing them would dramatically increase the cost of construction and the energy use of buildings due to the extra fan energy required. It would constitute a significant drag on our economy and waste of the planet’s natural resources. This proposal is nothing more than a bald faced, blatant attempt by two special interest groups to highjack the code process for benefit of their particular employers, but a significant detriment to society as a whole. It is supported by a plastic pipe manufacturer because, unlike metal pipes, plastic pipes cannot be located in a return air plenum. It is also supported by the sheet metal manufacturers association and the sheet metal workers union because it requires that buildings use more sheet metal. I strongly recommend that this proposal be rejected and that architectural return plenums continue to be allowed as they have for many years.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.
PUBLIC COMMENT 15:
SUBMITTER: Marshall Hunt, P.E., Pacific Gas & Electric Company

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The proponent fails to support the deletion with research. The proposal would have a significant impact on buildings, both new and existing (if undergoing a major remodel or renovation), with no documented research or studies to substantiate. The cost and energy consumption impacts will be significant.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 16:
SUBMITTER: Abdel K. Darwich, P.E., Guttmann & Blaevoet Consulting Engineers

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The proposed change of not allowing return air plenums in buildings is not properly documented. The proponent is making lots of statements without the proper technical substantiation to support them.
1. I disagree that the removed paragraph is a major loophole in the intent of providing safe and health air duct systems. ASHRAE 62.1 which is the major national standard on IAQ does not have any restriction on using return air plenums.
2. The proponent is claiming that the test in ASTM E84 is inappropriate, yet fails to state why it is so. Also, this test only applies to composite materials. Elementary materials will need to be tested per ASTM E136. Please note that ASTM E84 is a national standard referenced not only by UMC, but by IBC and NFPA as well. The adequacy of ASTM E84 to test certain materials should be addressed to ASTM and not to IAPMO.
3. The proponent is claiming that to meet the ASTM E84 requirements, building products are often laced with toxic fire retardants which can give off deadly gases. Has there been any research in this regard? How is “toxic” defined and measured? How is “deadly” defined and measured? Have there been any incidents where these toxic gases were released in an actual fire and resulted in casualties?
4. The proponent is claiming that the return air duct plenum will not result in lower cost if the total cost imposed on all other building trades were accounted for. Has this been scientifically justified by an independent cost analysis exercise?

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza
EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 17:
SUBMITTER: Karl Brown, California Institute for Energy and Environment

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Proposal Item # 155 precipitously and indiscriminately disallows a diverse variety of long-standing design approaches, without adequate substantiation. This proposal is not good code writing and should be rejected.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 18:
SUBMITTER: Steven Guttmann, P.E., Guttmann & Blaevoet Consulting Engineers

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

602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling systems shall be conducted through duct systems constructed of metal in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Rectangular ducts exceeding 2 inches (51 mm) w.g. shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible. 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 tightly sealed.

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.

Concealed building spaces or independent construction within buildings shall be permitted to be used as ducts or plenums, except in buildings where critical room pressure relationships shall be maintained at all times in accordance with the provisions of this code.

SUBSTANTIATION:
In Item # 155, it was proposed to eliminate the use of concealed building spaces as plenums or ducts. As noted by the Committee, this is a common industry practice in many building types. The one type where this practice is a threat to the health and safety of the public is in hospitals and other buildings requiring maintenance of critical room pressure relationships. The prohibition should be limited to these building types.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed language is vague and unenforceable.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
DIAS: I vote to accept the original code change proposal as I agree with the substantiation provided by the proponent.

PUBLIC COMMENT 19 (Assembly Action):
SUBMITTER: Craig Loeffler, Self

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

SUBSTANTIATION:
Return air plenums result in the risk of increased health and safety issues to the building occupants. I agree with the code change proponent’s rationale.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected as concealed spaces are commonly used as plenums or ducts.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
ADLER, DIAS: I disagree with the rejection of Public Comment 19, which was to accept the code change proposal as submitted. I vote to accept the original code change proposal and I agree with the substantiation of the proponent (Craig Loeffler).
SUBMITTER: David W. Ash
Lubrizol Advanced Materials, Inc.

RECOMMENDATION:
Revise text as follows:

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, except as indicated below.

Exceptions:
(1) - (11) (remaining text unchanged)
(12) Plastic plumbing piping exposed within a plenum shall have a flame spread index not to exceed 25 and a smoke-developed index not to exceed 50, where tested in accordance with ULC-S102.2, ASTM E84, or UL 723.

Note: ULC-S102.2 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee.

SUBSTANTIATION:
Currently ASTM E84 is the required test to determine the flame and smoke properties of materials. These values then determine whether or not a material may be used within plenums. There are exceptions to this standard for those products with special criteria and those are shown in Sections 602.2(1) through 602.2(11).

Since that test is specified by the UMC, all other products (including plastic plumbing pipe) must be evaluated by this test. The scope of ASTM E84 test states that it is applicable to surfaces such as walls and ceilings. Many products do not correspond to a flat shape. Although an ASTM committee has been attempting to decide on a test method for pipe, to date they have not been successful. Consequently, ASTM E84 does not provide any direction in testing a pipe.

Other test standards have been development that do include provisions for testing pipe. These standards have been successfully used for a number of years. The ULC-S102.2 standard recognizes that the appropriate way to evaluate the flame and smoke characteristics of a pipe is to test a sample in that shape.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed standard ULC-S102.2 does not provide the equivalent or superior test procedures for a smoked developed index as ASTM E84 or UL 723.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Michael Cudahy, Plastic Pipe and Fittings Association (PPFA)

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

SUBSTANTIATION: 
PPFA recommends approval based on the original proponent’s substantiation.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed standard ULC-S102.2 does not provide the equivalent or superior test procedures for a smoked developed index as ASTM E84 or UL 723.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CHURCH: We support alternatives to the current ASTM E84, although other standards are being developed and mounting requirements for ASTM E84 are considered.

PUBLIC COMMENT 2:
SUBMITTER: Forest Hampton III, Lubrizol Advanced Materials, Inc.

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

SUBSTANTIATION: 
ULC-S102.2-2010 provides a relevant method for testing flame and smoke properties of actual plastic pipes, fittings and valves. This method is representative of how pipes and assemblies are used in the field. This method has been in use since the 1980’s and has provided a safe determination of flame and smoke properties for use in air handling systems. Currently, ASTM E84 is the required test to determine the flame and smoke properties of materials. These values then determine whether or not a material may be used within plenums. There are exceptions to this standard for those products with special criteria and those are shown in Sections 602.2(1) through 602.2(11). Since that test is specified by the UMC, all other products (including plastic plumbing pipe) must be evaluated by this test. The scope of ASTM E84 test states that it is applicable to surfaces such as walls and ceilings. Many products do not correspond to a flat shape. Although an ASTM committee has been attempting to decide on a test method for pipe, to date they have not been successful. Consequently, ASTM E84 does not provide any direction in testing a pipe. Other test standards have been development that do include provisions for testing pipe. These standards have been successfully used for a number of years. The ULC-S102.2 standard recognizes that the appropriate way to evaluate the flame and smoke characteristics of a pipe is to test a sample in that shape.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed standard ULC-S102.2 does not provide the equivalent or superior test procedures for a smoked developed index as ASTM E84 or UL 723.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CUDAHY: We support alternatives to the current ASTM E84, although other standards are being developed and mounting requirements for ASTM E84 are considered.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 87)

RECOMMENDATION:
Revise text as follows:

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, except as indicated below.

Exceptions:
(1) Return-air and outside-air ducts, plenums, or concealed spaces that serve a dwelling unit shall be permitted to be of combustible construction.
(2) Air filters meeting in accordance with the requirements of Section 314.2 and Section 503.3.
(3) Water evaporation media in an evaporative cooler.
(4) Charcoal filters where protected with an approved fire suppression system.
(5) Materials listed and labeled for installation within plenums.

(6) Smoke detectors.
(7) Duct insulation, coverings, and linings and other supplementary materials complying installed in accordance with Section 604.0.
(8) Materials in a Group H hazardous Division 6, fabrication area including the areas above and below the fabrication area sharing a common 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. Exposed electrical equipment installed within a plenum shall be listed or labeled in accordance with UL 2043.

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 Loudspeakers and Recessed Lighting. Loudspeakers and recessed lighting fixtures, including their assemblies and accessories, in plenums shall be listed and labeled for use in plenums and shall have a peak rate of heat release not exceeding 134 horsepower (hp) (100 kW), an average optical density not exceeding 0.15, and a peak optical density not exceeding 0.5, where tested in accordance with UL 2043.

SUBSTANTIATION:
1. In Section 602.2, exceptions 5, 6, 7, and 8 are being relocated to their own sections, Section 602.2.1 through Section 602.2.4, for ease of use of the code.
2. The text “except as indicated below” is being deleted from Section 602.2 since the language is irrelevant since the items are already indicated as exceptions.
3. Exception 5 in Section 602.2 recognizes that combustible materials listed for the installation in plenums should be allowed. Materials listed for the installation within ducts or plenums shall have a flame spread index of not more than 25 and a smoke developed index of not more than 50 where tested in accordance with ASTM E84 or UL 723.
4. Exception 8 is being revised since the group and division number for occupancies will vary depending on the ordinance. The definition of “Group H” and “Division 6” is determined by the building code. Therefore, the divi-
sion number should be deleted and the Group H should be revised to hazardous fabrication areas. Materials located in hazardous fabrication areas are already present in the fabrication and the air circulation system for the area uses high velocity air to quickly sweep any contaminants from the space. Furthermore, fabrication areas prohibit the connection of ducts or plenums to other areas of the building thus minimizing the exposure of occupants to hazardous materials in other spaces.

5. The language added to Section 602.2.1 (Electrical) will require electrical equipment in plenums to be listed and labeled in accordance with UL 2043. UL 2043, which is commonly used in the industry, is a fire test method for determining the fire performance response of discrete products (including, but not limited to electrical equipment) intended to be installed in air handling spaces, such as above suspended ceilings or below floors. These products are subjected to an open flame ignition source and evaluated using a product calorimeter. UL 2043 is not a new standard; it is already required for loud speakers and recessed lighting fixtures.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Marguerite Carroll, UL, LLC

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

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) Return-air and outside-air ducts, plenums, or concealed spaces that serve a dwelling unit shall be permitted to be of combustible construction.
(2) Air filters in accordance with the requirements of Section 314.2 and Section 503.3.
(3) Water evaporation media in an evaporative cooler.
(4) Charcoal filters where protected with an approved fire suppression system.
(5) Materials Products listed and labeled for installation within plenums in accordance with Section 602.2.1 through Section 602.2.4.
(6) Smoke detectors.
(7) Duct insulation, coverings, and linings and other supplementary materials installed in accordance with Section 604.0.
(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.

SUBSTANTIATION:
As currently written, exception 5 is ambiguous and can lead to misinterpretations of the requirements for materials within a plenum. Materials which are used within a plenum are required to comply with ASTM E84 or UL 723 as indicated in Section 602.2. There are specific products that are listed and labeled for installation within plenums that do not meet these standards, but they have other established requirements and should be listed and labeled in accordance with those established requirements. These exceptions are clearly specified in current Sections 602.2.1 through 602.2.4. If products are to be exempt from the basic requirement in Section 602.2, those exceptions should be specifically stated in subsections to Section 602.2.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  
AFFIRMATIVE: 20  
NEGATIVE: 1  
NOT RETURNED: 1 Garza
EXPLANATION OF NEGATIVE:
CUDAHY: I still think that this code considers "items or products" as "material." In other words, a stack of pipe and fittings would be considered as material.

PUBLIC COMMENT 2:
SUBMITTER: Marguerite Carroll, UL, LLC

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

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. Exposed electrical equipment installed within a plenum shall be listed or labeled in accordance with UL 2043.

602.2.5 Discrete Products in Plenums. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

206.0 Discrete Products in Plenums. Individual, distinct products which are non-continuous such as pipe hangers, duct registers, duct fittings, and duct straps.

SUBSTANTIATION:
UL 2043, which is currently referenced in Section 602.2.1 for only electrical products, pertains to additional discrete products that are located in a plenum and have exposed combustible material such as pipe hangers, duct registers, and duct fittings. Section 602.2.5 was added to ensure these discrete products continue to provide an appropriate level of protection against cumulative flame spread and smoke generation from exposed materials within the plenum. UL 2043 is currently referenced in Table 1701.1. Furthermore, a definition for “discrete products in plenums” is being added as it is necessary to assist the end user in applying and enforcing this term.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Projects Appropriate for Comment since the comment introduces a new substantive change (discrete products in plenums) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”

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602.3 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 UL 181 and its class designation. These ducts shall be listed and shall be installed in accordance with the terms of their listing.

603.3 Factory-Made Air Ducts. Listed Class 0 or Class 1 factory-made air ducts and connectors shall be permitted to be listed in accordance with UL 181 and installed in accordance with the terms of their listing in an occupancy covered by this code. Factory-made air ducts shall not be used for vertical risers in air-duct systems serving more than two stories. Such ducts shall not penetrate a fire-resistance-rated construction where fire dampers are required. 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, they shall be protected from physical damage. The temperature of the air to be conveyed in a duct shall not exceed 250°F (121°C).

SUBSTANTIATION:
1. In Section 602.3, the reference to Chapter 17 is being replaced with a reference to UL 181 since it is the standard used in the industry for factory-made air ducts and connectors. Furthermore, text is being relocated to Section 603.3 since it is where the provisions for installation of ducts are addressed. UL 181 addresses requirements which include preformed lengths of flexible or rigid ducts, materials in the form of boards for field fabrication of lengths of rigid ducts, and preformed flexible air connectors.

2. In Section 603.3, the text “Listed Class 0 or Class 1 factory-made air ducts” is being replaced with “listed in accordance with UL 181” since the Class 0 and Class 1 requirements are part of the requirements for UL 181. Furthermore, the second paragraph is being revised to address the intent of the code section for clarity purposes.

3. All other changes are being done to comply with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Tim Ross, Ross Distributing Inc.

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

602.3 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.

602.53 Metal. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards-Metal and Flexible or duct systems in accordance with UL 181.
603.3 Factory-Made Air Ducts and Connectors. Factory-made air ducts and connectors shall be listed in accordance with UL 181 and installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

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).

SUBSTANTIATION.
Section 602.3 (Factory-Made Air Ducts) should be deleted as it is repetitive to Section 603.3 (Factory-Made Air Ducts). Section 602.3 (Metal) is being revised since UL 181 is only applicable to factory-made air ducts which is already stated in Section 603.3 (Factory-Made Air Ducts). Furthermore, Section 603.3 should be revised as factory-made air ducts and connectors should be installed in accordance with their listing and the manufacturer’s installation instructions.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

602.3 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.

602.5 Metal. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards-Metal and Flexible.

603.3 Factory-Made Air Ducts and Connectors. Factory-made air ducts and connectors shall be listed and labeled in accordance with UL 181 and installed in accordance with the terms of their listing and 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).

COMMITTEE STATEMENT:
Section 602.3 (Factory-Made Air Ducts) should not be deleted as it is necessary for enforcement purposes. Section 602.5 (Metal) should not be relocated to Section 602.3 for ease of use of the code. Section 603.3 (Factory-Made Air Ducts and Connectors) was revised to provide clarity in regards to the installation of factory-made air ducts and connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CARROLL: Although the Committee did a lot to amend the issues in this comment, the fact remains that there are factory made flexible ducts which are also metallic ducts. By creating separate sections for "metal" and for "factory made" ducts, there is a perceived delineation which creates confusion for those ducts which technically fall under both sections. The requirements for these products are covered under UL 181 and therefore the reference to UL 181 in Section 602.3 should not have been stricken.
PUBLIC COMMENT 2:
SUBMITTER: Ralph Koerber, ATCO Rubber Products, Inc./Rep. Air Diffusion Council (ADC)

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

602.3 Factory-Made Air Ducts and Air Connectors. Factory-made rigid or flexible air ducts, and flexible air connectors, shall be approved for the use intended and shall be tested in accordance with the requirements of UL 181. These air ducts or air connectors shall be listed and labeled, and shall be installed in accordance with the terms of their listing. Each portion of a factory-made air duct system shall be identified by the manufacturer with a label or other identification indicating compliance with UL 181 and its class designation.

603.3 Factory-Made Rigid or Flexible Air Ducts. Factory-made rigid or flexible air ducts shall be permitted to be installed in an occupancy covered by this code. These ducts shall be installed in accordance with the manufacturer’s installation instructions and connectors shall be listed in accordance with UL 181 and installed in accordance with the terms of their listing.

Factory-made air ducts shall not be used for vertical risers in air-duct systems serving more than two adjacent stories in height, and shall not penetrate a fire-resistance-rated construction where fire dampers are required.

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).

SUBSTANTIATION:
For Section 602.3, in looking at both Item # 158 and Item # 159 together, it appears that the Committee wants to be more expletive regarding the types of factory-made air ducts and factory-made air connectors, and to separate the requirement specifics for the ducts from the installation specifics of the ducts. The addition of the text “and Air Connectors” signifies that this section lays out the requirement for both air ducts and air connectors to meet the requirements of the UL 181 standard. Furthermore, the added text “rigid or flexible” and the use of the text “flexible” associated with air connectors more clearly describes the types of factory-made air ducts and air connectors covered by the scope of UL 181.

In addition, factory made air ducts and air connectors should be both approved for the use intended and they should be tested to the appropriate requirements in the UL 181 standard for the product. Lastly, it should be made clear that factory-made air ducts and air connectors must be listed and labeled to the UL 181 standard. Products cannot just simply be “in accordance with” or “comply to” the standard.

In Section 603.3, again the use of the text “rigid or flexible” clearly describes the type of factory-made air ducts referred to in the section. The text “serving more than two adjacent stories in height” and the limitation for air duct penetration where fire dampers are required are consistent with NFPA 90A and NFPA 90B.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 159  
UMC 2015 – (603.4):

SUBMITTER:  Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 94)

RECOMMENDATION:
Add new text as follows:

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

(renumber remaining sections)

SUBSTANTIATION:
(Attachments for Item 159 are included in the substantiation CD presented to the TC)

1. Many HVAC installations utilize flexible air ducts and connectors, and the UMC does not provide specific requirements for flexible air ducts and connectors that can be used by designers for factory-made air ducts.
2. Flexible air ducts are considered factory-made air ducts. However, a separate section for flexible air ducts and connectors is being added for ease of use of the code. Unlike flexible air ducts and connectors, not all factory-made air ducts are required to comply with UL 181. UL 181 addresses requirements which include preformed lengths of flexible or rigid ducts, materials in the form of boards for field fabrication of lengths of rigid ducts, and preformed flexible air connectors. The user is to refer to the manufacturer’s installation instructions and SMACNA for the installation of flexible air ducts since both sources will provide installation instructions for flexible air ducts and connectors.
3. The 5 feet limitation for flexible air duct connectors coincides with the 2009 ASHRAE Handbook and “HVAC Flexible Duct Pressure Loss Measurements” which is a study submitted by Texas A&M University.
4. Where protected, a flexible air duct is permitted to penetrate a fire-rated assembly and a flexible air connector is prohibited to penetrate an assembly (fire-rated or not). This is because an air connector is not tested for spread of flame.
5. The temperature limitation is the industry standard for warm air. The material in flexible air ducts and air connectors are only tested to resist a temperature up to 250°F (121°C).

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Marguerite Carroll, UL, LLC

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors 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 ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).
SUBSTANTIATION:
Flexible air connectors which are listed to UL 181 are allowed by the standard in lengths up to 14 feet. This product is specifically evaluated for the maximum length up to 14 feet, and the manufacturer's installation instructions are reviewed to ensure proper installation up to this length. The requirements for these flexible air connectors have been included in the UL 181 standard for over 35 years. UL closely monitors field reports submitted through its market surveillance program, and we have not been made aware of any field issues with these products in lengths up to 14 feet when properly installed in accordance with the listing and manufacturers installation instructions.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEGATIVE: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation is not in accordance with the standard (UL 181) or the listings for flexible connectors.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.
- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs.
0.042"/100') per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 2:

SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

Jeff Stein, P.E., Taylor Engineering LLC

RECOMMENDATION:

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:

I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare….” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075'/100' vs. 0.042'/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEGATIVE: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee's decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

• As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

• Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

• While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.
It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 3:
SUBMITTER: Craig Sarmento, Beutler Corporation

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
Flexible duct is an ubiquitous element in both residential and commercial HVAC systems. It is cost effective, safe, and in many applications more energy efficient than the metal ducts that would be used to replace it. The proponents of this change are in error in two ways: they are proposing this change based upon energy saving benefits alone, which is specifically outside the purview of the UMC, and the change will actually harm fire and life safety by reducing the number of projects that are subjected to inspection.

Safety of flexible duct systems does not appear to be an issue in this proposal, as neither the appropriate Technical Committee handling the safety of flexible duct systems nor even the proponent of this measure claim that there is a safety issue with existing duct systems. Instead, the proponent of this change makes an argument that is factually incorrect, as well as being inappropriate, and is based on energy savings.

It is factually incorrect in that by only detailing the type of material, but not dealing with other elements of duct design, it fails to take into account the efficiency of the entire system. By confusing the performance of a component with the overall performance of a system. The proponent of this change has made a fundamental error in evaluation. Furthermore, not only can larger flex duct have both lower static pressure drops and lower costs than a similar length of smaller diameter metal ductwork, flexible duct is much more easily formed into long changing radius curves needed in the actual built environment; further improving the true energy performance of a system that contains flexible duct to a system that contains metal duct. The point is further proven by the absence of compelling peer reviewed research to support the conclusion that systems using flexible duct use more energy than systems using metal ductwork.

It is inappropriate in the absence of evidence of both a compelling fire/life safety issue and a means to address it; and the UMC is the wrong venue to use. The purpose of the UMC is to “provide minimum standards to safeguard life or limb, health, property, and public welfare”, while other standards such as ASHRAE 90.1 or California’s own Title 24/Part 6 are focused directly upon energy.

Finally, there is a very substantial likelihood that adoption of such a proposal would actually reduce safety in buildings. The existing built environment, both residential and commercial, is designed assuming the use of flexible duct from the size of overhead plenums to the diameter of openings in open web trusses that the ducts must pass through the geometry of spaces. To arbitrarily mandate rigid ductwork into spaces that were specifically designed to accommodate flexible duct installations will impose tremendous burdens on replacement contractors. Those that chose to go around the rules will have a price advantage, but will also need to hide their work from inspectors, thereby driving more replacement projects underground. Thus, this proposal is a net negative to fire and life safety. There is no positive benefit from those who follow the rules, if it is adopted, and significantly negative safety implications by driving projects away from responsible contractors and inspectors.

For these reasons, I recommend in the strongest possible terms the deletion of the third sentence of Section 603.4.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEGATIVE: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee's decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacturer's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

• As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

• Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

• While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.
It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 4:
SUBMITTER: Marshall Hunt, P.E., Pacific Gas & Electric Company

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
The input by Steven Taylor is on point particularly in reference to the importance of duct sizing. Energy efficiency for buildings in California is covered by Title 24. If this was an energy issue, it would be in Title 24. The proponent should present their proposal to the relevant energy efficiency code organizations.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEUTRAL: 0 REJECTED: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture’s installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.
FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare…” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.
- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.
- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 5:
SUBMITTER: Jeffrey P. Blaevoet, P.E., Guttmann & Blaevoet Consulting Engineers

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
Restricting the length of flexible ductwork is an unnecessary burden on designers and building owners. There is no guarantee this will save energy or improve safety, and would increase construction costs. This could also be interpreted as a restriction on fabric ducts and other innovative products.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEGATIVE: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

• As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

• Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

• While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.
PUBLIC COMMENT 6:
SUBMITTER: Gurdaver Singh, Guttmann & Blaevooet Consulting Engineers

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
Restricting the length of flexible ductwork is an unnecessary burden on designers and building owners. There is no guarantee this will save energy or improve safety; however it would increase construction costs. Correct sizing the flexible duct, setting performance criteria, and making sure the installation is correct especially through walls, floors, and ceilings is more important if energy is the true concern. This change could also be interpreted as a restriction on fabric ducts and other innovative products that are used by designers to meet the higher energy efficiency targets set by the code. Unless there are safety or health concerns, the use of flexible ducts should be left to the design team as tool to use in awkward coordination situations in the field. The purpose of the UMC is to provide minimum standards to safeguard life or limb, health, property, and public welfare. Unless a rationale based on improving safety, health, etc. can be provided; this change should not be made.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEGATIVE: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacturer's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.
FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California's Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 7:
SUBMITTER: Art Williams, Air Systems

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connectors lengths shall not be more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
Industry best practices already allow for flexible duct lengths greater than 5 feet when proper size criteria and installation practices are followed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 16 NEGATIVE: 5 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consens- sus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.
PUBLIC COMMENT 8:
SUBMITTER: Glenn Friedman, P.E., Taylor Engineering LLC

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connectors lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
Limiting flexible duct length will not improve building safety and will increase first costs. This is also not an energy improvement because energy usage depends on duct sizing, not on the type of duct alone. Therefore, the language “lengths shall be not more than 5 feet (1524 mm)” should be deleted.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  
AFFIRMATIVE: 16  
NEGATIVE: 5  
NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacturer’s installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.
TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.
- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075"/100’ vs. 0.042"/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.
- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 9:
SUBMITTER: Reinhard Seidl, Taylor Engineering LLC

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air duct lengths shall not exceed 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
The stated reason for limiting flexible duct lengths to reduce pressure loss does not make sense from a technical perspective, and limiting the length of flex duct to 5 feet increases costs without benefits. All undersized ducts have too much pressure drop. It is the designer’s responsibility to size the duct (flexible or not) in accordance with the project’s energy goals and in compliance with energy codes. This has nothing to do with the material choice, and can be done with either flexible duct or hard duct. The proposed revision allows the designer the flexibility in coming to the correct design decision.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 16   NEGATIVE: 5   NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacturer’s installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

FEEHAN: The five foot limitation is not in accordance with the current standard or listings for flexible air connectors (UL 181). I agree with the substantiation submitted with the public comment. Also, limiting the length will increase construction cost.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare….” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.
- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.
- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.
PUBLIC COMMENT 10:
SUBMITTER: Stephen Poe, Critchfield Mechanical Inc

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer’s installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5'7" feet (1524-2134 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
Item # 159 proposes to limit flexible air ducts and connectors to 5 feet maximum length. Flexible air ducts are currently used for sound attenuation of airflow at virtually every supply diffuser in large commercial buildings. The standard acoustic flex duct for a diffuser in an office building is 7 feet in length. For example, you can Google “JP Lamborn Acoustic Ducting AMF-07.” The 7 foot length is required for adequate acoustic noise attenuation of the airflow as it enters the diffuser into the occupied space. The maximum length of the flexible air duct should be set at 7 feet, and not 5 feet.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

• As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.
• Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075″/100′ vs. 0.042″/100′) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.
• While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.
It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.

PUBLIC COMMENT 11:
SUBMITTER: Steven Guttmann, Guttmann & Blaevot Consulting Engineers

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

603.4 Flexible Air Ducts and Connectors. Flexible air ducts and connectors shall comply with UL 181, shall be installed in accordance with the manufacturer's installation instructions, and SMACNA HVAC Duct Construction Standards - Metal and Flexible. Flexible air ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) in facilities where critical room pressure relationships shall be maintained at all times in accordance with other provisions of this code and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
The proposed deletion eliminates the limitation of "flexible air connector" lengths. The justification by the submitter was that this aligns with the 2009 ASHRAE Handbook. However, the handbook does not require this limitation, but rather suggests the trade-offs in increased air flow resistance (and thus, energy use) should be considered. Energy concerns can be offset in other ways, and does not require this length limitation. For decades, California has limited the use of flexible air ducts to 10 feet, but only in hospitals due to concerns about installation methods with longer flex ducts causing potential air balance problems in a facility that has critical air balance requirements. Furthermore, the limitation of lengths for "air connectors" but not "air ducts" is confusing, as the paragraph uses both terms in other sentences but not in this one, even though for all intents and purposes they refer to the same manufactured item. The proposed length limitation does not appear to improve the health, safety, or welfare of the public in any meaningful way.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken for Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 12:
SUBMITTER: Christine Tsai/Craig Malaer/ Kristopher Kyle, Webcor Builders

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
Flex duct is, technically, a perfectly acceptable solution. To install sheet metal duct where flex duct can be installed only serves to increase the revenue of the installers and manufacturers.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken for Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 17 NEGATIVE: 4 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).

CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare....” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leakage and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.
PUBLIC COMMENT 13:
SUBMITTER: Ralph Koerber, ATCO Rubber Products, Inc./Rep. Air Diffusion Council (ADC)

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

603.4 Factory-Made Flexible Air Connectors. Factory-made flexible air connectors shall be permitted to be installed in an occupancy covered by this code. Air connectors shall be installed in accordance with the manufacturer's installation instructions and with their listing.

Factory-made air connectors shall not pass through a wall, partition, or enclosure of a vertical shaft that is required to have a fire resistance rating of 1 hour or more. Factory-made air connectors shall not exceed 14 feet (4267 mm) in length and shall not pass through floors.

Factory-made air connectors 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 an air connector shall not exceed 250°F (121°C).

SUBSTANTIATION:
The recommendations for Section 603.3 (Item # 158) clarifies the installation requirements for factory-made rigid and flexible air ducts. Therefore, Section 603.4 is necessary to clarify the installation requirements for factory-made flexible air connectors due to their limited-use boundaries. Factory-made rigid and flexible air ducts are already covered in Section 603.3, so only flexible air connectors should be included in this section. The modification clearly indicates that the section pertains to the installation of factory-made flexible air connectors. Factory-made flexible air connectors, just as with factory-made air ducts, should be installed in accordance with the manufacturer's installation instructions and the listing. Furthermore, including the requirement to install products per the SMACNA HVAC Duct Construction Standards - Metal and Flexible may conflict with UL 181 and SMACNA, as they have different requirements. The code language already requires, in Section 602.3, that factory-made air ducts and air connectors be installed per the conditions of their listing which are included in the manufacturer’s installation instructions.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken for Item # 160 as it provides clarity in regards to the 5 feet length limitation for flexible air connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 17 NEGATIVE: 4 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacturer's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

Secondly, no attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

CABOT: The five foot limitation conflicts with the flexible air connectors standard (UL 181).
CARROLL: The five foot limitation on flexible air connectors is not in accordance with the standard or the listings for these products.

TAYLOR: I strongly recommend striking the third sentence from Section 603.4 as it limits the length of flexible duct. The purpose of the UMC (Section 101.2) “is to provide minimum standards to safeguard life or limb, health, property, and public welfare...” Limiting flexible duct length does not meet any of these goals and it will unnecessarily increase first cost. The rationale provided by the proponent is improved energy efficiency. However:

- As noted above, energy efficiency is not under the purview of the UMC. Energy standards, such as ASHRAE 90.1, California’s Title 24, etc. explicitly cover this scope yet neither of these standards include any direct restriction on flex duct length. Why? Because these standards are based on life cycle cost analysis and no one has ever shown that flex duct increases life cycle costs.

- Even if energy efficiency was a valid premise, this proposal is incomplete. Fan energy depends not only on the roughness of the duct but on how it is sized. A 8 inch diameter “smooth” sheet metal duct conveying 200 cfm will have almost twice the friction rate of a 10 inch “very rough” flexible duct conveying 200 cfm (0.075”/100’ vs. 0.042”/100’) per SMACNA data. The UMC does not address how to size ducts (e.g. limit friction rate) so it is quite possible that contractors will install 8 inch metal ducts instead of 10 inch flexible ducts to offset the cost premium of metal vs. flexible and increasing energy use in doing so.

- While flex leak duct is rougher than a sheet metal duct, it has two advantages over sheet metal. It reduces leak- age and improves insulation. First, leakage is reduced because there are no longitudinal joints at all, and generally fewer transverse joints because flex ducts come in long lengths (up to 25 feet in one section), and requires no offsets. Sheet metal duct offsets are often made with adjustable elbows which have very high leakage. Second, insulation is improved because it is installed perfectly (factory installed around the whole duct) and protected by a tough plastic barrier vs. field installed duct wrap that is clipped on and easily ripped off. These two benefits of flex duct are likely to offset any energy impact of increased duct roughness.

It is important to understand who is really behind this proposal and why. I suspect that the sheet metal unions are behind it because it requires more sheet metal and will be more money in their pockets. But the effect on society will be negative because it will drive up the cost of construction.
Item # 160

UMC 2015 – (603.3.1):

SUBMITTER:  David Dias
Sheet Metal Worker's Local 104

RECOMMENDATION:
Add new text as follows:

**603.3.1 Factory-Made Flexible Air Ducts and Connectors.** 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 ridged elbows or fittings.

SUBSTANTIATION:
More often than not flexible ducts are not installed to SMACNA standards. They are not cut to proper lengths, strapped at proper intervals, used for elbows, punctured, pinched off, and damaged in other ways resulting in a poor installation and excessive energy wasted. By limiting flexible ducts to 5 feet most of these problems are eliminated.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed change is overly restrictive and would ban the installation of flexible air ducts that are longer than 5 feet.

Note: Item # 160 failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT (Assembly Action):
SUBMITTER: Craig Loeffler, Self

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

SUBSTANTIATION:
Flexible duct is being used beyond its original intent. More often than not the flex is not installed properly or cut to proper length, creating compression and sag. When used as elbows, the radius is often very tight pinching or choking off the duct. Flex is also susceptible to rodents chewing through the flex or dropping feces in the air stream that cannot be cleaned without being damaged. These problems will result in improper air flow which has an adverse effect on the efficiency of the HVAC system, and reduces the IEQ (Indoor Environmental Quality) for the building occupants in which can have an effect on their health and safety. Looking at the numerous other studies and reports, which have been around for over a decade showing the problems with flex duct being improperly installed, we can conclude the problems with the longevity of the flex duct system and airflow issues still exist. By limiting flex duct to 5'-0" the aforementioned problems are greatly reduced or eliminated altogether.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:
603.3.1 Factory-Made Flexible Air Ducts and Connectors. 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 ridged rigid elbows or fittings.

Exception: Residential occupancies.

COMMITTEE STATEMENT:
The proposed modification will clarify the intent of the section in regards to the use of factory-made flexible air ducts and connectors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 18 NEGATIVE: 3 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BUUCK: Even though an exception was added to exempt residential occupancies, I have to vote negative on this ballot item for the precedence it sets. My reason is based on the lack of any evidence in the proponent’s substantiation (as well as the Committee statement) and the fact that the Committee did not try to address any of the issues mentioned.

Furthermore, I have a couple issues with the Committee’s decision to restrict flexible air connectors to a length of 5 feet. First, there was very little data offered to support the decision. No data was given, only personal experience, to prove that this was really a widespread issue. As was stated in the substantiation for Public Comment 1, UL is not aware of any field issues with these products when installed per the listing and the manufacture's installation instructions. Before something this restrictive is approved for the code, the Committee should have much stronger evidence to stand on.

No attempt was made to address the main problems that some Committee members saw regarding the product, namely resistance to airflow and sagging, beyond shortening the allowable length to an arbitrary number. I understand that the number is in the 2009 ASHRAE Handbook, but, unlike UL 181, it is not an ANSI consensus standard with the required due process and openness. If the Committee really wanted to address the issues, they could have. The code already requires flex connectors to be one size larger than smooth duct, and, as the submitter of Public Comment 2 stated, 10 inch flexible duct has less friction than an 8 inch smooth duct.

Finally, the new language which states that flexible connectors “shall not be used in lieu of rigid elbows or fittings” would seem to defeat the purpose of flexible connectors altogether, since they are made to replace the elbows required to make the last connection between a duct or plenum and a diffuser. This could be construed as banning flexible connectors from all commercial occupancies. This language is unclear and will lead to inconsistent and overly-restrictive enforcement.

CARROLL: The public comment should be rejected based on the following reasons:
A. There was some important information that was not considered when we discussed this proposal (and Item #159). It is my understanding that ASHRAE was going to speak on this at the UMC TC meeting in Las Vegas but were not present for Item #160. The following was taken verbatim from the ASHRAE TC5.2 Duct Design committee minutes in conclusion to numerous meetings on this specific subject with the recommendation that the code not limit the length of air duct or connectors.

The final vote of ASHRAE TC5.2 Duct Design was recorded as:
"The Chair enters the following motion, second by Ralph Koerber, for a vote of ASHRAE TC5.2 (Duct Design) as follows:
1. The ASHRAE 2009 Fundamentals Handbook (page 21.7 and 21.18) reads that “for commercial systems, flexible ducts should be... no more than 5 ft in length, full stretched.”
2. This is also included in the more recent 2013 handbook; however, the limiting length recommendation was changed to 6 feet.
3. This was intended to give design guidance to the engineer and was never intended to be included in code language such as "shall be limited to 5 feet."
4. It is the recommendation of the ASHRAE Technical Committee TC5.2 duct design that any code language limiting the length of flexible duct or air connectors, due to language in the ASHRAE Handbook as referenced above, to 5 or 6 feet be stricken."

B. Discussions at the UMC TC meetings indicated two potential concerns with flexible duct – improper installation and loss of airflow due to inadequate extension. Limiting the length of flexible duct and flexible air connectors to 5 feet will NOT ensure proper installation of these products and will not ensure proper extension and air flow. What this limitation WILL do is add significant construction costs.

TAYLOR: Not only is there no substantiation for the 5 foot limit as a safety or public health consideration (see my public comments on # 159), the last clause of this proposed change makes no sense: flex ducts are in fact primarily used to make connections from rigid ducts to air outlets which generally includes a change in direction from horizontal to vertical that would constitute an elbow. Does this language mean that flex duct has to be run only dead straight? This has no purpose other than to increase construction costs.
UMC 2015 – (603.2.5):

SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 93)

RECOMMENDATION:
Delete text without substitution:

603.2.5 Lateral Load. Ducts shall be braced and guyed to prevent lateral or horizontal swing.

SUBSTANTIATION:
Section 603.2.5 is being deleted since there is no technical justification for supports to exceed the requirements of SMACNA HVAC Duct Construction Standard. For example, there is no need to brace/guyed in a non-seismic setting.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The language pertaining to lateral load is necessary to be consistent with the standard practice used throughout the industry. Furthermore, the substantiation provided is incorrect as it is not a seismic issue, but a current industry practice to maintain the structural integrity of the duct system.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Eli Howard, SMACNA

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

SUBSTANTIATION:
The current industry ANSI/SMACNA HVAC Duct Construction Standard for duct construction provides the means/methods, within Chapter 5, for the hanging and supporting of ductwork. Ductwork is permitted to be hung in its static state (weight of duct & insulation), or with a maintenance load (250 lb concentrated at center point of ductwork) if required by the designer for the service of the duct. Once the ductwork is hung in its static state, it would only move if a force is applied to the duct. Hence, if no force is applied to the duct, it will not move. The use of a guyed to prevent lateral or horizontal swing is not a standard practice in the industry, nor outlined in the SMACNA HVAC Duct Construction Standard. However, if the ductwork in question is within a defined seismic zone (see ASCE 7) then there are requirements as to how the ductwork must be braced to prevent lateral or horizontal swing (see ANSI/SMACNA Seismic Bracing Manual). Additionally, ductwork installations may also need to comply with certain state requirements such as OSHPD. Therefore, removing the language in Section 603.2.5 will provide clarity for the code official, contractor, and designer. There will also be a potential cost reduction in areas where seismic bracing is not required, and therefore no added costs for the installation of guyed bracing.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 172

UMC 2015 – (605.1 – 605.3):

SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Revise text as follows:

605.1 Smoke Dampers. Smoke dampers shall comply be listed or labeled in accordance with the standards for leakage-rated dampers referenced in Chapter 17 UL 555S, and shall be installed in accordance with the manufacturer’s installation instructions where required by the building code. Smoke dampers shall be labeled by an approved agency.

605.2 Fire Dampers. Fire dampers shall comply be listed or labeled in accordance with the standard for fire dampers referenced in Chapter 17 UL 555, and shall be installed in accordance with the manufacturer’s installation instructions where required by the building code. Fire dampers have been tested for closure under airflow conditions and shall be labeled for both maximum airflow permitted and direction of flow. Where more than one damper is installed at a point in a single air path, the entire airflow shall be assumed to be passing through the smallest damper area. Fire dampers shall be labeled by an approved agency.

Ductwork shall be connected to damper sleeves or assemblies in accordance with the fire damper manufacturer’s installation instructions.

605.3 Ceiling Radiation Dampers. Ceiling radiation dampers shall comply be listed or labeled in accordance with the standard for ceiling radiation dampers referenced in Chapter 17 UL 555C, and shall be installed in accordance with the manufacturer’s installation instructions in the fire-resistive ceiling element of floor-ceiling and roof-ceiling assemblies where required by the building code. Fire dampers not meeting the temperature limitation of ceiling radiation dampers shall not be used as a substitute. Ceiling radiation dampers shall be labeled by an approved agency.

SUBSTANTIATION:
1. The revisions to Section 605.1 through Section 605.3 will provide guidance to the end user to what standards smoke, fire, and ceiling radiation dampers should be listed or labeled.
2. UL 555S includes a comprehensive set of construction and performance requirements that are used to evaluate and list smoke dampers. It is the basic standard used to evaluate smoke dampers. The requirements in UL 555S cover smoke dampers intended for use in heating, ventilation, and air conditioning (HVAC) systems. Furthermore, it addresses the construction, testing, classification, marking, installation, and operating of smoke dampers.
3. UL 555 includes a comprehensive set of construction and performance requirements that are used to evaluate and list fire dampers. It is the basic standard used to evaluate fire dampers. The requirements in UL 555 cover fire dampers intended for use in heating, ventilation, and air conditioning (HVAC) systems. Furthermore, it addresses the construction, performance testing, marking requirement, and installation instructions of fire dampers (dynamic and static).
4. UL 555C includes a comprehensive set of construction and performance requirements that are used to evaluate and list ceiling radiation dampers. It is the basic standard used to evaluate ceiling dampers. The requirements in UL 555C cover ceiling dampers intended for use in heating, ventilation, and air conditioning (HVAC) systems. Furthermore, it addresses the construction, performance testing, and installation instructions of ceiling dampers (dynamic and static).
5. All the above proposed standards are listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

605.1 Smoke Dampers. Smoke dampers shall comply be listed or labeled in accordance with UL 555S, and shall be installed in accordance with the manufacturer’s installation instructions where required by the building code.
605.2 Fire Dampers. Fire dampers shall comply be listed or labeled in accordance with UL 555, and shall be installed in accordance with the manufacturer’s installation instructions where required by the building code. Fire dampers shall have been tested for closure under airflow conditions and shall be labeled for both maximum airflow permitted and direction of flow. Where more than one damper is installed at a point in a single air path, the entire airflow shall be assumed to be passing through the smallest damper area.

Ductwork shall be connected to damper sleeves or assemblies in accordance with the fire damper manufacturer’s installation instructions.

605.3 Ceiling Radiation Dampers. Ceiling radiation dampers shall comply be listed or labeled in accordance with UL 555C, and shall be installed in accordance with the manufacturer’s installation instructions in the fire-resistive ceiling element of floor-ceiling and roof-ceiling assemblies where required by the building code. Fire dampers not meeting the temperature limitation of ceiling radiation dampers shall not be used as a substitute.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Arnold Rodio, Pace Setter Plumbing, Corp.

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

605.0 Smoke Dampers, Fire Dampers, and Ceiling Dampers.

605.1 General. Dampers shall be provided where required by the building code. Dampers for hazardous and commercial kitchen exhaust shall comply with Chapter 5. Where combination fire and smoke dampers are installed, such dampers shall comply with the requirements of the smoke damper and fire damper standards in accordance with Section 605.2 and Section 605.3.

SUBSTANTIATION:
1. Reference to Chapter 5 is being added to advise the user that dampers used for commercial kitchens can be found in Chapter 5. Furthermore, language is being added to indicate to the user that were combination dampers are used, the combination damper needs to comply with both the fire and smoke damper standards: outlined in Section 605.2 (Smoke Dampers) and 605.3 (Fire Dampers).

2. The definition for “ceiling radiation damper” should be relocated to Section 206.0 with the rest of the other definitions for dampers for case of use.
3. The definitions for “fire damper” and “smoke damper” are being revised as the text “listed to the applicable recognized standard” should not be part of the definition. The applicable recognized standard is already referenced within Section 605.0 (Smoke Dampers, Fire Dampers, and Ceiling Dampers). All other revisions were made for clarity.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment creates confusion as it addresses exhaust dampers that are within the scope of the building code and not the UMC.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
605.2.1 Dynamic Fire Dampers. In systems where fans continue to operate in the emergency mode, dynamic fire dampers shall be installed. [NFPA 5000:8.8.8.2.2]

605.4 Damper Rating. Fire dampers shall be designed and tested in accordance with UL 555 and shall have the minimum fire protection rating specified in Table 605.4 for the rating assembly penetrated. [NFPA 5000:8.8.8.2.1] Smoke damper leakage ratings shall be not less than Class II, and the elevated temperature ratings shall be not less than 250°F (121°C). [NFPA 5000:8.10.5.5]

<table>
<thead>
<tr>
<th>FIRE RESISTANCE RATING OF ASSEMBLY</th>
<th>MINIMUM DAMPER RATING (hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3-hour fire resistance-rated assemblies</td>
<td>$\frac{1}{2}$</td>
</tr>
<tr>
<td>3-hour or greater fire resistance-rated assemblies</td>
<td>$\frac{3}{2}$</td>
</tr>
</tbody>
</table>

605.5 Damper Actuation. Dampers shall be actuated in accordance with the building code.

605.7 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.

SUBSTANTIATION:
1. Proposed Section 605.2.1 requires dynamic fire dampers to be installed in systems where fans continue to operate in emergency mode. Fire dampers used in duct systems where fans will be on during a fire incident, and are expected to be able to operate (close) against the air require testing under such conditions, such as the dynamic closure test specified in UL 555.

2. Proposed Section 605.4 addresses the minimum rating requirements for dampers. Fire dampers will be required to comply with Table 605.4 which summarizes the required hourly rating for fire dampers based on the fire resistance-rated assembly. The fire damper rating is consistent with the building code and UL 555. Furthermore, smoke damper leakage rating shall not be less than Class II, and the elevated temperature ratings shall not be less than 250°F which is consistent with building code and UL 555S. An air leakage limit is required to minimize noise, cost, and waste of energy. The temperature requirement for an elevated temperature must not be less than 250°F since it is the minimum temperature used for the temperature degradation test for smoke dampers. A combination fire and smoke damper must comply with the requirements of both a fire damper and a smoke damper.

3. Section 605.5 is being added since the end user has no guidance to where damper actuation provisions are obtained from, and the building code indicates specific provisions for the actuation of fire, smoke, fire/smoke, and ceiling radiation dampers.

4. Section 605.7 is not necessary as damper ratings are addressed in Section 605.4.
COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed text was disapproved based on the concern that the language is incomplete as it does not include the entire NFPA 5000 requirements in regards to dynamic dampers.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Arnold Rodio, Pace Setter Plumbing, Corp

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

605.1.1 Damper Rating. Smoke damper leakage ratings shall be not less than Class II, and the elevated temperature ratings shall be not less than 250°F (121°C). [NFPA 5000:8.10.5.5]

605.2.1 Damper Rating. Fire dampers shall have the minimum fire protection rating in accordance with Table 605.2.1 for the rating assembly penetrated.

<table>
<thead>
<tr>
<th>FIRE RESISTANCE RATING OF ASSEMBLY</th>
<th>MINIMUM DAMPER RATING (hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-hour or greater fire resistance-rated assemblies</td>
<td>1</td>
</tr>
<tr>
<td>Less than 3-hour fire resistance-rated assemblies</td>
<td>1 1/2</td>
</tr>
<tr>
<td>Ceiling of floor/ceiling or roof/ceiling assemblies</td>
<td>See Section 605.3.1</td>
</tr>
</tbody>
</table>

605.3.1 Damper Rating. Ceiling radiation dampers, or other methods of protecting openings in fire resistance-rated floor/ceiling or roof/ceiling assemblies shall comply with the construction details of the tested floor/ceiling or roof/ceiling assembly, or protected with listed ceiling air diffusers or listed ceiling radiation dampers in accordance with Section 605.3.

605.4 Damper Actuation. Dampers shall be actuated in accordance with the building code.

(renumber remaining sections)

605.7 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.

SUBSTANTIATION:
1. The Technical Committee reason for rejecting the proposal was that the language was incomplete as it did not include the entire NFPA 5000 requirements in regards to dynamic dampers. Therefore, provisions pertaining to dynamic dampers have been removed and the provisions for fire, smoke, and ceiling dampers are being proposed as the Committee had no issues in regards to such provisions.
2. Table 605.2.1 has been modified by adding the minimum damper rating for a ceiling of floor/ceiling or roof/ceiling assemblies to correlate with NFPA 5000. Section 605.3.1 is being added to be consistent with the requirements of NFPA 5000 in regards to the damper rating for ceiling radiation dampers.
3. Section 605.7 is not necessary as damper ratings are already addressed in Section 605.1.1 in regards to temperature ratings.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment addresses damper provisions that are outside the scope of the UMC as it is within the purview of the building code.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Add new text as follows:

802.5.1.1 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]

SUBSTANTIATION:
Section 802.5.1.1 will assure consistency with NFPA 211. UL 103 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built chimneys for residential-type and building heating appliances. UL 959 includes a comprehensive set of construction and performance requirements that are used to evaluate and list medium heat factory-built chimneys. These standards are currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

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

802.5.1.1 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]

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.

203.0
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).

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).

SUBSTANTIATION:
1. In Section 802.5.1.1, provisions pertaining to venting of wood-burning appliances should be deleted as it is out of the scope of the venting requirements addressed in Chapter 8. For informational purposes only, Section 801.3 is shown as follows: 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.

2. In Section 801.2, the text “and medium-heat” should be added as medium-heat appliances are within the scope of Chapter 8 and UL 959. Furthermore, the definitions for “appliance, low-heat” and “appliance, medium-heat” are necessary as they are referenced within Chapter 8 without being defined. The proposed definitions assist the end user in applying and enforcing these terms.
COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

802.5.1.1 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]

COMMITTEE STATEMENT:
Section 802.5.1.1 is being modified to keep the provisions that are necessary for the enforcement of factory-built chimneys and to correlate with NFPA 211.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure Section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (new definitions for low and medium heat appliances and revision to Section 801.2) not published in the ROP as part of the proposal being commented on. The committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Add new text as follows:

**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.

SUBSTANTIATION:
UL 103 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built chimneys for residential-type and building heating appliances. UL 127 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built fireplaces and includes the chimney requirements. UL 1482 includes a comprehensive set of construction and performance requirements that are used to evaluate and list solid-fuel type room heaters and includes the chimney requirements.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

**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.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

RECOMMENDATION:
Request to **reject** the code change proposal by this public comment.

SUBSTANTIATION:
1. Section 802.5.1.1 should be deleted as the standards UL 103, UL 127, or UL 1482 do not address requirements specific to decorative shrouds. Furthermore, Section 802.5.4.3 indicates that decorative shrouds shall be listed and labeled for such use. For informational purposes only, Section 802.5.4.3 is shown as follows: **802.5.4.3 Decorative Shrouds.** Decorative shrouds shall 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]

2. Furthermore, UL 1482 is not applicable as it is a standard that is used for solid-fuel type room heaters used with a factory-built chimney and not for a factory-built chimney.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes requirements that are necessary for the enforcement of decorative shrouds.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: UMC Technical Committee Comment

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

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.

SUBSTANTIATION:
UL 103 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built chimneys for residential-type and building heating appliances. UL 127 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built fireplaces and includes the chimney requirements. UL 1482 includes a comprehensive set of construction and performance requirements that are used to evaluate and list solid-fuel type room heaters and includes the chimney requirements.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 190  Comment Seq # 053
UMC 2015 – (802.6.5, 802.6.6, 803.2.3, Figure 802.6.6):

SUBMITTER:  Dave Levanger
Chair, Technical Correlating Committee (TCC) (see TCC Report Item # 67)

RECOMMENDATION:
Revise text as follows:

802.6.5  **802.6.4.1 Habitable Occupiable Space.** Appliances connected to the common vent shall be located in rooms separated from an **habitable 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 **habitable occupiable** space. (See Figure 802.6.5 802.6.4.1) [NFPA 54:12.7.4.2]

802.6.6  **802.6.4.2 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 803.1.3(7), provided the following apply:

1. The 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. (See Figure 802.6.6)

2. The size of the connector for a segment is determined from the appliance’s gas input rate and 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, shall be based on the total appliance’s **gas heat input rate** entering that segment and its total height. [NFPA 54:12.7.4.3]

(renumber remaining sections)

803.2.3  **Ten Percent Reduction.** 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 connector manifold ($LM$) shall not exceed 18 inches per inch (18 mm/mm) of common vent diameter ($D$). (See Figure 802.6.6) [NFPA 54:13.2.4]

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**FIGURE 802.6.6**
USE OF MANIFOLDED COMMON VENT CONNECTOR
[NFPA 54: FIGURE G.1(k)]

**SUBSTANTIATION:**
Sections 802.6.5, 802.6.6, and 803.2.3 are being revised to correlate with NFPA 54-2012. Figure 802.6.6 of the UMC is being deleted as this figure is a duplicate and is already shown in Appendix F, Figure F 1.0(k). Sections 802.6.5 and 802.6.6 of the UMC are being relocated to correlate with the UPC.
COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

802.6.4.2 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 803.1.3(7), provided the following apply:

1) The 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. (See Figure 802.6.6)

2) The size of the connector for a segment is determined from the appliance’s gas input rate and 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, shall be based on the total appliance’s gas input rate entering that segment and its total height. [NFPA 54:12.7.4.3]

803.2.3 Ten Percent Reduction. 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 \((0.90 \times \text{maximum common vent capacity})\) 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 \((18 \text{ mm/mm})\) of common vent diameter \((D)\). [NFPA 54:13.2.4] (See Figure 802.6.6)

![Figure 802.6.6 USE OF MANIFOLDED COMMON VENT CONNECTOR](NFPA 54: FIGURE G.1(k))

COMMITTEE STATEMENT:
Figure 802.6.6 should not be deleted as it provides the AHJ with access to a figure that may be useful for the enforcement of this section.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 UPC Item # 163 “Listing” resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

802.1.1 Listing. Gas vents shall comply with UL 441, UL 641, or UL 1738.
TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The new Section 802.1.1 (Listing) of the UMC will correlate with the actions taken by the UPC TC to “accept as submit” Item # 163.

The reason provided by the UPC TC for “accepting as submitted” Item # 163 is as follows: **UL 441 includes a comprehensive set of construction and performance requirements that are used to evaluate and list Type B and Type B-W venting systems. UL 641 includes a comprehensive set of construction and performance requirements that are used to evaluate and list Type L venting systems. UL 1738 includes a comprehensive set of construction and performance requirements that are used to evaluate and list special gas vents intended for venting Listed Category II, III or IV gas-burning appliances as defined by ANSI Z223.1/NFPA 54, “National Fuel Gas Code.” UL 641 and UL 1738 are in addition to the current listing in Table 1401.1.**

The following proposed action moves forward as approved by the TCC and supersedes any recommendation from the UMC TC.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

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

**802.1.1 Listing.** Type B and Type B-W gas vents shall comply with UL 441, and Type L gas vents shall comply with UL 641, or UL 1738.

SUBSTANTIATION:
Section 802.1.1 is being revised as UL 441 only applies to Type B and Type B-W gas vents, and UL 641 only applies to Type L gas vents. Furthermore, Table 802.4 indicates that venting systems used for Categories II, III, and IV appliances shall be in accordance with the manufacturer’s instructions; therefore, UL 1738 should be deleted as it only applies to Category II, III, and IV appliances.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

**802.1.1 Listing.** Type B and Type B-W gas vents shall comply with UL 441, and Type L gas vents shall comply with UL 641, and special gas vents shall comply with UL 1738.

COMMITTEE STATEMENT:
The proposed modification will put back the reference to UL 1738 as it is necessary for enforcement purposes and to provide clarity in regards to the listing of special gas vents.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: **AFFIRMATIVE:** 21 **NOT RETURNED:** 1 Garza

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, but only as neces-
sary 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 # 183.01 and UPC Items # 163 resulted in a conflict within this code in regards to listing of gas vents. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

**802.1.1 Listing.** Type B and Type B-W gas vents shall comply with UL 441, and Type L gas vents shall comply with UL 641, and special gas vents shall comply with UL 1738.

<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 1738-2010*</td>
<td>Venting Systems for Gas-Burning Appliances, Categories II, III, and IV (with revisions through May 13, 2011)</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

**TCC COMMITTEE ACTION:** Accept as Submitted

**TCC COMMITTEE STATEMENT:**
The revision to Section 802.1.1 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as submitted” Item # 163.

The substation provided by the UPC (Item # 163) for removing UL 1738 from Section 509.1.1 (Listing) is as follows: 1. “The UPC only contains provisions for Category I venting systems for water heaters as indicated throughout Section 510.0 (Sizing of Category I Venting Systems) and all of the sizing tables [Table 510.1.2(1) through Table 510.2(9)]. Furthermore, that is why Section 506.1.1 (Other Types of Appliances) requires appliances other than natural draft or Category I to be provided with combustion, ventilation, and dilution air in accordance with the manufacturer’s instructions; this is because Chapter 5 does not contain provisions for Categories II, III, and IV venting systems.”

2. “If UL 1738 is referenced in Chapter 5, it will conflict with the actions of the UPC Technical Committee (TC) during the 2012 code cycle, where the TC made a concerted effort to delete sections of the code that pertained to Categories II, III & IV venting systems [Section 510.1.1 (Categories), Section 510.6.3.2 (Category II, Category III, and Category IV Appliances), and Section 510.11 (Vent Connectors for Category II, Category III, and Category IV Appliances)].”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on Section 802.1.1 in regards to listing of gas vents.
902.0 General.

902.1 Nonindustrial Gas 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 equipment. \[NFPA 54:10.1.1\] For additional information concerning particular appliances and accessories, including industrial types, reference can be made to the standards listed in Chapter 17. \[NFPA 54:10.1.1\]

903.3 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. \[NFPA 54:10.2.3(1)\]

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, rear and in accordance with the manufacturer’s installation instructions. \[NFPA 54:10.2.3(2)\]

3. Listed and unlisted air-conditioning appliances (listed and unlisted) installed in rooms that are large in comparison with the size of the appliance, shall be permitted to be installed with reduced clearances to combustible material, provided the combustible material or appliance is protected as described in Table 802.7.3.4(2), see Footnote 2, and such reduction is allowed by the manufacturer’s installation instructions. \[NFPA 54:10.2.3(4)\]

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 not more than 2 inches (51 mm). \[NFPA 54:10.2.3(5)\]

5. Listed air-conditioning appliances shall have the clearance from supply ducts, within 3 feet (914 mm) of the furnace plenum, of not less than that specified from the furnace plenum. No clearance is necessary beyond this distance. \[NFPA 54:10.2.3(6)\]

903.6 Refrigeration Coils. The installation of refrigeration coils shall be in accordance with (See Section 904.8 and Section 904.9) \[NFPA 54:10.2.6\]

904.2 Clearance. Central heating boilers and furnaces shall be provided with clearances in accordance with the following:

1. 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. \[NFPA 54-12:10.3.2.1\]

2. 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 and such reduction is allowed by the manufacturer’s installation instructions. \[NFPA 54-12:10.3.2.2\]

3. Listed 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 in accordance with Table 802.7.3.4(2) and Figure 904.2(1) through Figure 904.2(3), and such reduction is allowed by the manufacturer’s installation instructions. \[NFPA 54:10.3.2.4\]

4. – (5) (remaining text unchanged)

6. The clearance to these appliances shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing. (See Section 304.0, Section 701.0, and Section 802.12.6) \[NFPA 54:10.3.2.4\]
(7) (remaining text unchanged)

(8) 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 54-42:10.3.2.8]

(9) (remaining text unchanged)

904.5 Low-Water Cutoff. Hot water boilers installed above the radiation level and steam boilers shall be provided with an automatic means to shut off the fuel supply to the burner(s) where the boiler water level drops to 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 where the flow rate is not capable of protecting the boiler against overheating. [NFPA 54:10.3.5]

904.8 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) – (4) (remaining text unchanged)

1311.13.5 Installation of Gas-Mixing Machines. Installation of gas-mixing machines shall comply with the following:

(1) The machine shall be located in a large, well-ventilated area or in a small detached building or cutoff room provided with room construction and explosion vents in accordance with sound engineering principles. Such rooms or below finished grade installations shall have approved positive ventilation.

(2) – (5) (remaining text unchanged)

SUBSTANTIATION:
Sections 902.1, 903.3, 903.6, 904.2, 904.5, 904.8, and 1311.13.5 are being revised to correlate with NFPA 54-2012.

COMMITTEE ACTION: Accept as Submitted

Note: Item # 196 failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT (Assembly Action):
SUBMITTER: Robert Christman, Local 38

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The manufacturer's installation instructions and listing standards are not always the same. Therefore, both requirements are needed for necessary life/safety installations. Having both aids in inspection and enforcement.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza
EXPLANATION OF AFFIRMATIVE:

CARROLL: I agree with Paul Cabot that an appliance should be installed in accordance with their listing and the manufacturer’s installation instructions. UL does review the MII’s as part of the listing. However, I do not know if other certification organizations do this as well. My understanding is that it is not an accreditation requirement and some organizations may not do this.

I also believe that when text is taken from a consensus document it should be taken verbatim and in full unless there is very good reason to change it. In this case, I am voting affirmative on the Committee action to correlate the language with the NFPA 54 document, however, I believe further clarification is needed in the future to ensure proper installation of listed appliances.

EXPLANATION OF NEGATIVE:

CABOT, TAYLOR: The listing contains the required installation instructions for a properly installed appliance. Both terms are not needed. The Committee should reject the comment.
SUBMITTER:  Bob Eugene
UL LLC

RECOMMENDATION:
Revise text as follows:

903.0 Air-Conditioning Appliances. (Gas-Fired Air Conditioners and Heat Pumps).

903.1 Electric Air Conditioners. Electric air conditioning systems shall be listed or labeled in accordance with UL 1995 or UL 60335-2-40.

903.2 Gas-Fired Air Conditioners and Heat Pumps. Gas-fired air conditioners shall comply with Section 903.2.1 through Section 903.2.7.

903.1 903.2.1 Independent Gas Piping. (remaining text unchanged)

903.2 903.2.2 Connection of Gas Engine-Powered Air Conditioners. (remaining text unchanged)

903.3 903.2.3 Clearances for Indoor Installation. (remaining text unchanged)

903.4 903.2.4 Assembly and Installation. (remaining text unchanged)

903.5 903.2.5 Furnace Plenums and Air Ducts. (remaining text unchanged)

903.6 903.2.6 Refrigeration Coils. (remaining text unchanged)

903.7 903.2.7 Switches in Electrical Supply Line. (remaining text unchanged)

TABLE 1701.0

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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<tr>
<td>UL 60335-2-40-2012*</td>
<td>Household and Similar Electrical Appliances, Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers</td>
<td>Appliances</td>
<td>903.1</td>
</tr>
</tbody>
</table>

Note: UL 60335-2-40 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
Section 903.1 will expand provisions to include electric air conditioning systems that are currently not addressed in the code. UL 1995 includes a comprehensive set of construction and performance requirements that are used to evaluate and list air conditioning systems. Section 903.2 is being added for ease of use of the code. UL 60335-2-40 is a new tri-national standard and includes a comprehensive set of construction and performance requirements that are used to evaluate and list air conditioning systems. The industry is at the beginning of a transition period to move air conditioning systems from UL 1995 to UL 60335-2-40. Table 1701.0 is being revised as UL 60335-2-40 is not currently listed in the table. UL 1995 is currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

903.1 Electric Air Conditioners. Electric air conditioning systems shall be listed or labeled in accordance with UL 1995 or UL 60335-2-40.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Tim Ross, Ross Distributing Inc.

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

903.1 Electric Air Conditioners. Electric air conditioning systems furnaces and heat pumps shall comply with UL 1995 or UL 60335-2-40.

SUBSTANTIATION.
The modification to Section 903.1 will provide clarity in regards to what type of electric air conditioning equipment the section is dealing with. It will clarify that UL 1995 should only apply to electric furnaces and heat pumps as UL 1995 also addresses condensing units and fan units which can be part of a system package, and therefore would be unenforceable by the AHJ. Furthermore, UL 60335-2-40 is unnecessary as UL 1995 is the standard used for electric furnaces and heat pumps, it is not necessary to indicate both standards as they both address similar requirements. Lastly, UL 60335-2-40 uses requirements from the international standard (IEC), which can cause a conflict with UL 1995.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The Technical Committee rejected the public comment in favor of Public Comment 2. Furthermore, the public comment removes requirements that are necessary for the enforcement of electric air conditioners.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2:
SUBMITTER: Marguerite Carroll, UL, LLC

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

903.1 Electric Air Conditioners. Electric air conditioning systems designed for permanent installation shall comply with UL 1995 or UL 60335-2-40.

SUBSTANTIATION:
Section 903.1 is being modified to clarify that air conditioning units listed and labeled in accordance with UL 1995 or UL 60335-2 are stationary equipment designed for permanent installation in contrast to products that are portable, or designed for window installations, which are also listed and labeled in accordance with UL 484.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 203  
UMC 2015 – (905.0 – 905.2.6):

SUBMITTER:  Bob Eugene  
UL LLC

RECOMMENDATION:
Revise text as follows:

905.0 Clothes Dryers.
905.1 Electric Clothes Dryers. Commercial electric clothes dryers shall be listed or labeled in accordance with UL 1240 and installed in accordance with the manufacturer’s installation instructions. Residential and coin-operated electric clothes dryers shall be listed or labeled in accordance with UL 2158 and installed in accordance with the manufacturer’s installation instructions.

905.2 Gas-Fired Clothes Dryers. Gas-fired clothes dryers shall comply with Section 905.2.1 through Section 905.2.6.

905.1 905.2.1 Clearance. (remaining text unchanged)
905.2 905.2.2 Exhausting to the Outdoors. (remaining text unchanged)
905.3 905.2.3 Provisions for Makeup Air. (remaining text unchanged)
905.4 905.2.4 Exhaust Ducts for Type 1 Clothes Dryers. (remaining text unchanged)
905.5 905.2.5 Exhaust Ducts for Type 2 Clothes Dryers. (remaining text unchanged)
905.6 905.2.6 Multiple-Family or Public Use. (remaining text unchanged)

SUBSTANTIATION:
UL 1240 includes a comprehensive set of construction and performance requirements that are used to evaluate and list commercial clothes dryers. UL 2158 includes a comprehensive set of construction and performance requirements that are used to evaluate and list residential and coin-operated electric clothes dryers. UL 1240 and UL 2158 are currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

905.1 Electric Clothes Dryers. Commercial electric clothes dryers shall be listed or labeled in accordance with UL 1240 and installed in accordance with the manufacturer’s installation instructions. Residential and coin-operated electric clothes dryers shall be listed or labeled in accordance with UL 2158 and installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Dan Buuck, National Association of Home Builders (NAHB)

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

905.1 Electric Clothes Dryers. Commercial electric clothes dryers that are intended to be used by trained personnel shall comply with UL 1240 and installed in accordance with the manufacturer’s installation instructions. Residents...
Household electric clothes dryers and commercial electric clothes dryers that are intended for general public use shall comply be in accordance with UL 2158 and installed in accordance with the manufacturer’s installation instructions.

**SUBSTANTIATION:**
The proposed modifications to Section 905.1 are necessary to accurately reflect the scope and purpose of UL 1240 and UL 2158. UL 1240 addresses commercial electric clothes dryers that are to be used by trained personnel only, and not by the general public. UL 2158 addresses household electric clothes dryers and commercial electric clothes dryers (including coin-, ticket-, or card-operated dryers) that are intended for general public use.

**COMMITTEE ACTION:** Reject the public comment

**COMMITTEE STATEMENT:**
The public comment is being rejected as the proposed language is ambiguous and unenforceable.

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**

- AFFIRMATIVE: 21
- NOT RETURNED: 1 Garza
Submitter: Dave Levanger  
Chair, Technical Correlating Committee (TCC) (see TCC Report Items # 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182)

Recommendation: Revise text as follows:

905.0 Clothes Dryers.

905.1 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) – (3) (remaining text unchanged)

907.2 Installation. A decorative appliance for installation in a vented fireplace shall be installed in a vented fireplace having a working chimney flue and constructed of noncombustible materials. These appliances shall not be thermostatically controlled:

(1) A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer’s installation instructions.

(2) – (3) (remaining text unchanged)

908.2 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) – (4) (remaining text unchanged)

910.1 Application. Direct gas-fired industrial air heaters of the recirculating type shall be designed and certified to be listed in accordance with CSA Z83.18. [NFPA 54:10.9.1]

910.7 Relief Openings. The design of the installation shall include 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:

(1) The structure’s designed infiltration rate and the size of relief opening(s) shall be determined by approved engineering methods.

(2) 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]

911.1 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 listing and the manufacturer’s installation instructions. In no case shall the clearance be such as to interfere with combustion air and accessibility. (See Section 304.0 and Section 701.0)

(2) (remaining text unchanged)

911.6 Duct Furnaces Used with Refrigeration Systems. Duct furnaces used with refrigeration systems shall be installed in accordance with the following:
Duct furnaces used in conjunction with cooling equipment 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 tight to prevent a circulation of cooled air through the unit.

912.0 Floor Furnaces. 912.1 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.

913.0 Food Service Appliance, Floor Mounted. 913.1 Clearance for Listed Appliances. Listed floor-mounted food service appliances, such as ranges for hotels and restaurants, deep-fat fryers, unit broilers, gas-fired 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 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 their listing and the manufacturer’s installation instructions. Appliances designed and marked, “For use only in noncombustible locations,” shall not be installed elsewhere. [NFPA 54:10.12.1]

913.2 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. Clearances for unlisted appliances installed in partially enclosed areas such as alcoves shall not be reduced. Where clearances for unlisted appliances installed in rooms that are not partially enclosed are reduced, the combustible material or the appliance shall be protected as described in accordance with Table 802.7.3.4(2). [NFPA 54:10.12.2]

913.3 Mounting on Combustible Floor. 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 their listing and the manufacturer’s installation instructions.

914.2 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 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. [NFPA 54:10.13.2]

916.1.1 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.

916.1.2 Vertical Clearance Above Cooking Top. Household 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. 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. [NFPA 54:10.15.1.2]
916.2.1 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. [NFPA 54:10.15.2.1]

916.2.2 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) – (2) (remaining text unchanged)

(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. [NFPA 54:10.15.2.2]

917.0 Illuminating Appliances.

917.1 Clearances for Listed Appliances. Listed illuminating appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions. [NFPA 54:10.16.1]

917.5 Gas 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 54:10.16.5]

919.3 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) – (3) (remaining text unchanged)

921.1 Listed Units. Listed outdoor cooking appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions. [NFPA 54:10.20.1]

922.2 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.

(remaining text unchanged)

924.3 Clearance. A room heater shall be placed so as not to cause a hazard to walls, floors, curtains, furniture, doors where open, and so on, 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 arranged 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 924.3(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. [NFPA 54:10.23.4]

926.0 Gas-Fired Toilets.

926.1 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. [NFPA 54:10.25.1]
927.2 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) – (3) (remaining text unchanged)

927.2.1 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) – (4) (remaining text unchanged)

928.0 Wall Furnaces.
928.1 Installation. Wall furnaces shall be installed in accordance with the following:

(1) 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. [NFPA 54:10.27.1.1]

(2) (remaining text unchanged)

(3) Vented wall furnaces connected to a Type B-W gas vent system listed for a single story shall be installed 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 928.1. 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. (See Figure 928.1 for Type B-W gas vent installation) [NFPA 54:10.27.1.3]

(4) Direct-vent wall furnaces shall be installed with the vent-air intake terminal in the outside atmosphere 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 54:10.27.1.4]

(5) (remaining text unchanged)

**SUBSTANTIATION:**
Sections 905.1, 907.2, 908.2, 910.1, 910.7, 911.1, 911.6, 912.1, 913.1 – 913.3, 914.2, 916.1.1, 916.1.2, 916.2.1, 916.2.2, 917.1, 917.5, 919.3, 921.1, 922.2, 924.3, 926.1, 927.2, 927.2.1, and 928.1 are being revised to correlate with NFPA 54-2012.

**COMMITTEE ACTION:** Accept as Submitted

**Note:** Item # 204 failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-3.5.2 of the Regulations Governing Committee Projects, a public comment is requested for this proposal. The technical committee will reconsider this proposal as a public comment.

**PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**

**PUBLIC COMMENT (Assembly Action):**

**SUBMITTER:** Robert Christman, Local 38

**RECOMMENDATION:**
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
The manufacturer’s installation instructions and listing standards are not always the same. Therefore, both requirements are needed for necessary life/safety installations.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
CARROLL: I agree with Paul Cabot that an appliance should be installed in accordance with their listing and the manufacturer's installation instructions. UL does review the MII's as part of the listing. However, I do not know if other certification organizations do this as well. My understanding is that it is not an accreditation requirement and some organizations may not do this.

I also believe that when text is taken from a consensus document it should be taken verbatim and in full unless there is very good reason to change it. In this case, I am voting affirmative on the Committee action to enable the correlation of the language with the NFPA 54 document, however, I believe further clarification is needed in the future to ensure proper installation of listed appliances.

EXPLANATION OF NEGATIVE:
CABOT, TAYLOR: The appliance listing includes all important installation instructions and therefore the term "and it's listing" is not needed.
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Add new text as follows:

909.0 Fireplaces and Stoves.
909.1 Factory Built Fireplaces. Factory built fireplaces shall be listed or labeled in accordance with UL 127 and installed in accordance with the manufacturer’s installation instructions.
909.1.1 Gasketed Fireplace Doors. A gasketed fireplace door shall not be installed on a factory-built fireplace, except where the fireplace system has been tested, and listed or labeled for such use in accordance with UL 127.
909.2 Fireplace Stoves. Fireplace stoves shall be listed or labeled in accordance with UL 737 and installed in accordance with the manufacturer’s installation instructions.
909.3 Fireplace Accessories. Heat exchangers, glass doors assemblies, combustion air vents and termination caps shall be listed or labeled in accordance with UL 907 and installed in accordance with the manufacturer’s installation instructions.

(renumber remaining sections)

SUBSTANTIATION:
Providing a single section for fireplaces and stoves will reduce confusion with installations of such products. UL 127 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built fireplaces. UL 737 includes a comprehensive set of construction and performance requirements that are used to evaluate fireplace stoves. UL 907 includes a comprehensive set of construction and performance requirements that are used to evaluate and list fireplace accessories. These standards are currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

909.1 Factory Built Fireplaces. Factory built fireplaces shall be listed or labeled in accordance comply with UL 127 and installed in accordance with the manufacturer’s installation instructions.
909.1.1 Gasketed Fireplace Doors. A gasketed fireplace door shall not be installed on a factory-built fireplace, except where the fireplace system has been tested, and listed or labeled for such use in accordance with UL 127.
909.2 Fireplace Stoves. Fireplace stoves shall be listed or labeled in accordance comply with UL 737 and installed in accordance with the manufacturer’s installation instructions.
909.3 Fireplace Accessories. Heat exchangers, glass doors assemblies, combustion air vents and termination caps shall be listed or labeled in accordance comply with UL 907 and installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
909.0 **Solid-Fuel-Type Fireplaces and Stoves.**

909.1 **Factory-Built Fireplaces.** Factory-built fireplaces intended for use with solid wood or coal fuels shall comply be in accordance with UL 127 and installed in accordance with the manufacturer’s installation instructions.

909.1.1 **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.

909.2 **Fireplace Stoves.** Fireplace stoves intended for use with solid wood or coal fuels shall comply with UL 737 and installed in accordance with the manufacturer’s installation instructions.

909.3 **Fireplace Accessories.** Heat exchangers, glass doors assemblies, combustion air vents, and termination caps installed on or in existing masonry fireplaces shall comply be in accordance with UL 907 and installed in accordance with the manufacturer’s installation instructions.

**SUBSTANTIATION:**

1. Section 909.0 should be modified as the corresponding standards (UL 127, 737, and UL 907) are applicable only to solid fuels such as wood or coal.

2. Section 909.1 should be modified as the current language will require that all factory-built fireplaces to comply with UL 127. However, UL 127 is only applicable to solid wood or coal fuels. Furthermore, Section 909.1.1 is unnecessary as such requirements are already addressed within UL 127.

3. Section 909.2 should be modified as the current language will require that all fireplace stoves to comply with UL 737. However, UL 737 is only applicable to fireplace stoves intended for use with solid wood or coal.

4. Section 909.3 should be modified as the current language will require that fireplace accessories installed on any fireplace shall comply with UL 907. However, UL 907 is only applicable to fireplace accessories installed on or in existing masonry fireplaces.

**COMMITTEE ACTION:** Reject the public comment

**COMMITTEE STATEMENT:**
The public comment removes provisions that are necessary for the health and safety of the public.

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**

**AFFIRMATIVE:** 21  
**NOT RETURNED:** 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 112)

RECOMMENDATION:
Add new text as follows:

911.10 Electric Duct Heaters. Electric duct heaters shall be installed in accordance with NFPA 70.

SUBSTANTIATION:
The code does not provide the user with directions needed for the safe installation of air duct heaters. NFPA 90A (Section 4.2.4.5.2) requires duct heaters to comply with NFPA 70 (Section 424.57). NFPA 70 provides installation requirements such as distances to heat pumps or air conditioning appliances, condensation, interlocks, limit controls, installation, etc. The addition to Section 911.10 will provide the end user the direction needed for the safe installation of air duct heaters.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
This proposal was rejected in favor of Item # 050 which clarifies that electrical equipment shall comply with NFPA 70. Furthermore, the language is unnecessary as it does not include any installation provisions.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Dan Buuck, National Association of Home Builders (NAHB)

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

911.10 Electric Duct Heaters. Electric duct heaters shall be installed in accordance with NFPA 70. within an air duct shall be listed for such use 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.

911.10.1 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.

911.10.2 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.

207.0
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.

SUBSTANTIATION:
The Technical Committee felt that the language was unnecessary as it did not indicate any installation provisions. Therefore, installation provisions that are consistent with industry standards are being proposed. Reference to NFPA 70 is still required for clearance requirements for the energized portions of the equipment. Furthermore, a definition for “electric duct heater” is being added as the term is being used without being defined. The proposed definition assists the end user in applying and enforcing the term.
COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The term "interlocked" needs to be better defined (does a flow proving switch count??), or simply delete the sentence since all UL listed duct heaters are required to have flow proving devices - an additional electrical interlock to the fan is not needed and can be very expensive in a central air system with remote heating coils.
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Revise text as follows:

916.1 Electric Household Cooking Appliances. Electric household cooking appliances shall be listed or labeled in accordance with UL 1026, UL 1082, or UL 1083 and installed in accordance with the manufacturer’s installation instructions.

916.2 Household Electric Ranges. Household electric ranges shall be listed or labeled in accordance with UL 858 and installed in accordance with the manufacturer’s installation instructions.

916.3 Gas-Fired Household Cooking Appliances. Gas-fired household cooking appliances shall comply with Section 916.4 through Section 916.5.4.

916.4 916.4 Floor-Mounted Units. Floor mounted units shall be installed in accordance with Section 916.1.1 through Section 916.1.2.916.4.2.

916.1.1 916.4.1 Clearance from Combustible Material. (remaining text unchanged)

916.1.2 916.4.2 Vertical Clearance Above Cooking Top. (remaining text unchanged)

916.2 916.5 Built-In Units. (remaining text unchanged)

916.2.1 916.5.1 Installation. (remaining text unchanged)

916.2.2 916.5.2 Vertical Clearance. (remaining text unchanged)

916.2.3 916.5.3 Horizontal Clearance. (remaining text unchanged)

916.2.4 916.5.4 Level Installation. (remaining text unchanged)

### TABLE 1701.0
**REFERENCED STANDARDS**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1082-2009*</td>
<td>Household Electric Coffee Makers and Brewing-Type Appliances (with revisions through June 17, 2011).</td>
<td>Electric Appliances</td>
<td>916.1</td>
</tr>
<tr>
<td>UL 1083-2009*</td>
<td>Household Electric Skillets and Frying-Type Appliances (with revisions through June 17, 2011).</td>
<td>Electric Skillets, Frying-Type Appliances</td>
<td>916.1</td>
</tr>
</tbody>
</table>

Note: UL 1082 and UL 1083 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

(partial of table not shown remain unchanged)

**SUBSTANTIATION:**
UL 1026, UL 1082, and UL 1083 include a comprehensive set of construction and performance requirements that are used to evaluate and list household cooking appliances. UL 858 includes a comprehensive set of construction and performance requirements that are used to evaluate and list household electric ranges. Renumbering is editorial. Table 1701.0 is being revised as UL 1082 and 1083 are not currently listed in the table. UL 1026 is currently listed in Table 1701.0.

**COMMITTEE ACTION:** Accept as Amended by the TC
Amend proposal as follows:

916.1 Electric Household Cooking Appliances. Electric household cooking appliances shall be listed or labeled in accordance with UL 1026, UL 1082, or UL 1083 and installed in accordance with the manufacturer’s installation instructions.
916.2 Household Electric Ranges. Household electric ranges shall comply with UL 858 and installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

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

916.1 Electric Household Cooking Appliances. Electric household cooking appliances designed for permanent installations shall comply with UL 1026, UL 1082, or UL 1083 and be installed in accordance with the manufacturer’s installation instructions.

916.2 Household Electric Ranges. Household electric ranges shall comply with UL 858 and installed in accordance with the manufacturer’s installation instructions.

(SUBSTANTIATION:
1. Section 916.1 should be modified as the proposed standards are outside the scope of the UMC. For example: UL 1026 applies to appliances such as toasters, rotisserie, or other specific appliances which are not designed for permanent installation; UL 1082 applies to appliances such as portable electric coffee makers, percolators, coffee urns, and other brewing-type appliances; and UL 1083 applies to appliances such as portable electric household skillets and other frying-type appliances.
2. In Section 916.2, the text “and installed in accordance with the manufacturer’s installation instructions” should be deleted as it is already stated in Section 916.1. Furthermore, Section 916.2 is being combined with Section 916.1 for ease of use of the code.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 113)

RECOMMENDATION:  
Add new text as follows:

923.0 Sauna Heaters.  
923.1 General. Sauna heaters shall be listed and installed in accordance with the manufacturer’s installation instructions. Approved guards or barriers shall be installed to prevent accidental contact with the sauna heater. Ventilation shall be provided in accordance with the listing and combustion air for gas-fired sauna heaters shall comply with Chapter 7.

(renumber remaining sections)

SUBSTANTIATION:  
Section 923.1 will require a sauna heater to be listed and installed in accordance with the manufacturer’s installation instructions. The location of the heater shall be such that it cannot be accidentally touched as touching the top of the heater could cause severe burns. Therefore, guards should be required since the rocks/stones of the sauna heater get very hot and in order to reduce the risk of accidental contact, provisions for heater guards must be added. Ventilation requirements are being added since incorrect ventilation, or an incorrectly located sauna heater, can under certain circumstances cause excessive drying of the wood in the sauna and create a fire hazard. Ventilation requirements for sauna heaters are typically dictated by its listing, such as UL 875 for electric sauna heaters. Combustion air for gas-fired sauna heaters shall comply with Chapter 7.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:  
The proposed revision is too restrictive for residential occupancies.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:  
SUBMITTER: Tim Ross, Ross Distributing, Inc.

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

923.0 Sauna Heaters.  
923.1 General. Sauna heaters shall be listed and installed in accordance with the manufacturer’s installation instructions. Approved guards or barriers shall be installed to prevent accidental contact with the sauna heater. Ventilation shall be provided in accordance with the listing and combustion air for gas-fired sauna heaters shall comply with Chapter 7.

SUBSTANTIATION:  
The Technical Committee felt that the proposed language pertaining to guards was too restrictive for residential occupancies. Therefore, the guard and barrier provisions have been removed.

COMMITTEE ACTION: Reject the public comment
COMMITTEE STATEMENT:
The public comment is being rejected as the provisions are too restrictive for residential occupancies.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Revise text as follows:

924.0 Room Heaters.

924.1 Electric Room Heaters. Electric room heaters shall be listed or labeled in accordance with UL 2021.

924.2 Gas-Fired Room Heaters. Gas-fired room heaters shall comply with Section 924.2.1 through Section 924.2.4.

924.4 924.2.1 Prohibited Installations. (remaining text unchanged)

924.1.1 924.2.1.1 Unvented Room Heaters. (remaining text unchanged)

924.2 924.2.2 Installations in Institutions. (remaining text unchanged)

924.3 924.2.3 Clearance. (remaining text unchanged)

924.4 924.2.4 Wall-Type Room Heaters. (remaining text unchanged)

SUBSTANTIATION:
Section 924.1 will address the minimum provisions for electric room heaters which will require them to comply with UL 2021. Currently the code is silent on this issue and the end user has no guidance to the minimum requirements for electric room heaters. UL 2021 includes a comprehensive set of construction and performance requirements that are used to evaluate and list electric room heaters. UL 2021 is currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

924.1 Electric Room Heaters. Electric room heaters shall comply with UL 2021.

COMMITTEE STATEMENT:
There is no need to cite "listed or labeled" throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

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

924.1 Electric Room Heaters. Electric room heaters shall comply with UL 2021. NFPA 70.

SUBSTANTIATION:
1. Reference to UL 2021 should be replaced with reference to NFPA 70 as it addresses the minimum requirements for fixed electric space-heating equipment. Furthermore, UL 2021 does not apply to all types of electric room heaters; for example, electric baseboard heaters. Lastly, the proposed language will be in conflict with NFPA 70-2014 (Section 424.6) as NFPA only requires the room heater to be listed, but it does not require the room heater to comply with a specific listing; therefore, eliminating the use of other types of electric room heaters.
2. Though the section applies to fixed type electric room heaters, it does not apply to permanent installations. There are electric room heaters in the market, such as panel heaters or electric wall heaters that are listed to UL 2021 which can be easily removed and replaced by heating equipment. Therefore, the reference to UL 2021 is unnecessary as it does not guarantee the AHJ that the section will be met. All electrical equipment must be in accordance with the minimum safety standards indicated by NFPA 70, including any electrical equipment listed to UL 2021.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes the reference to UL 2021 which is necessary for the enforcement of the section. Furthermore, UL 2021 is the appropriate standard for electric room heaters.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Add new text as follows:

924.5 Solid-Fuel Room Heaters. Solid-fuel room heaters shall be listed or labeled in accordance with UL 1482.

SUBSTANTIATION:
Section 924.5 will address the minimum provisions for solid-fuel room heaters which will require them to comply with UL 1482. Currently the code is silent on this issue and the end user has no guidance to the minimum requirements for solid-fuel room heaters. UL 1482 includes a comprehensive set of construction and performance requirements that are used to evaluate and list solid fuel room heaters. UL 1482 is currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

924.5 Solid-Fuel Room Heaters. Solid-fuel room heaters shall be listed or labeled in accordance with UL 1482.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Marguerite Carroll, UL, LLC

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

924.5 Solid-Fuel-Type Room Heaters. Solid-fuel-type room heaters shall comply with UL 1482.

SUBSTANTIATION:
Section 924.5 should be modified to be consistent with the scope of UL 1482.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Bob Eugene
UL LLC

RECOMMENDATION:
Add new text as follows:

936.0 Burner Assemblies.
936.1 Oil Burners. Oil burners shall be listed or labeled in accordance with UL 296 and installed in accordance with the manufacturer’s installation instructions.
936.2 Gas Burners. Commercial gas burners shall be listed or labeled in accordance with UL 295 and installed in accordance with the manufacturer’s installation instructions.

TABLE 1701.0
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
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<tbody>
<tr>
<td>UL 295-2007*</td>
<td>Commercial-Industrial Gas Burners (with revisions through September 21, 2012)</td>
<td>Gas Burners</td>
<td>936.2</td>
</tr>
</tbody>
</table>

Note: UL 295 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

(PORTIONS OF TABLE NOT SHOWN REMAIN UNCHANGED)

SUBSTANTIATION:
UL 296 includes a comprehensive set of construction and performance requirements that are used to evaluate and list oil burners. UL 295 includes a comprehensive set of construction and performance requirements that are used to evaluate and list gas burners. Table 1701.0 is being revised since UL 295 is currently not listed in the table. UL 296 is currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

936.1 Oil Burners. Oil burners shall be listed or labeled in accordance comply with UL 296 and installed in accordance with the manufacturer’s installation instructions.
936.2 Gas Burners. Commercial gas burners shall be listed or labeled in accordance comply with UL 295 and installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Phil Ribbs, PHR Consultants

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
1. The proposed language is unenforceable and too prescriptive as burners are components used within an appliance.
2. The proposed standards are already required in other standards such as UL 726 and UL 795.
3. It eliminates the use of other standards such as CSA B140 or CSA B140.2.1.
4. Current industry standards for gas-or fuel-burning appliances already have minimum burner provisions necessary for the safe operation of the appliance. For example, CSA Z21.10.1 and CSA Z21.10.3 provide minimum burner requirements that are required for the appliance to function properly and as intended. Therefore, UL 295 and UL 296 should be addressed in the appliance standard, and not the UMC which is a minimum code. The AHJ should be enforcing that the appliance is properly listed, and not the components within the appliance.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes the listing requirements for burner assemblies which are necessary for the enforcement of the section.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Item # 218.01
UMC 2015 - (936.2):

SUBMITTER:   UMC Technical Committee Comment

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

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 comply with UL 586 and be installed in accordance with the manufacturer’s installation instructions.

SUBSTANTIATION:
UL 586 should be removed from Section 936.2 as it contains for third party listing that is in violation of the commercial terms and conditions in accordance with ANSI. Section 7.2 indicates that “as a confirmation of results of tests by the manufacturer, three samples from each line of filter units having similar design and construction are to be tested at Air Techniques International, 1708 Whitehead Road, Suite 104, Baltimore, Maryland for compliance with requirements in 7.1.1.” Having such requirement is in direct violation with Section 3.2 (Commercial terms and conditions) of the ANSI procedures. For information purposes only, Section 3.2 is shown as follows: “Provisions involving business relations between buyer and seller such as guarantees, warranties, and other commercial terms and conditions shall not be included in an American National Standard. The appearance that a standard endorses any particular products, service or companies must be avoided. Therefore, it generally is not acceptable to include manufacturer list, service provider lists, or similar material in the text of the standard or in an annex (or the equivalent). Where a sole source exists for essential equipment, material or services necessary to comply with or to determine compliance with the standard, it is permissible to supply the name and address of the source in a footnote or informative annex as long as the words “or the equivalent” are added to the reference. In connection with standards that relate to the determination of whether products or services conform to one or more standards, the process or criteria for determining conformity can be standardized as long as the description of the process or criteria is limited to technical and engineering concerns and does not include that would otherwise be a commercial term.”

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21   NOT RETURNED: 1 Garza
RECOMMENDATION:
Add new text as follows:

936.0 Ductless Mini-Split Systems.

936.1 General. A ductless mini-split system shall be installed in accordance with the manufacturer’s installation instructions and Section 936.2 and Section 936.3.

936.2 Water Level Monitoring Device. A water-monitoring device shall be installed inside of the main drain pan of ductless mini-split systems. Such device shall shut off the equipment in the event that the primary drain becomes restricted. Devices installed in the drain line shall not be permitted.

936.3 Condensate. Where ductless mini split equipment produces condensate, the equipment shall be provided with an inline check valve located in the drain line, or a trap. Where a ductless mini-split system is not capable of draining condensate from the unit by gravity, a condensate pump shall be installed to remove water from the unit. The condensate pump shall be powered by the same power supply that serves the equipment and shall be capable of shutting off the equipment in the event of failure of the pump to remove condensate.

206.0 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.

SUBSTANTIATION:
Ductless mini-split systems have existed for more than 50 years and have numerous applications in apartments, commercial, and institutional buildings. The most common applications are in multifamily housing or as retrofit add-ons with “non-ducted” heating systems, such as hydronic (hot water heat), radiant (electric resistance), and space heaters (wood, kerosene, propane). They are a commonly used option for room additions and small apartments where extending or installing distribution ductwork (for a central air-conditioner or heating system) is not feasible or where existing equipment cannot handle the additional load.

Unlike an air conditioning window unit; it is a permanently installed mechanical system used in new construction, additions, multi-family (condo/apartment) housing, and to improve comfort in poorly conditioned spaces, and requires a permit to be installed. Therefore, the code must adequately address these types of systems.

Ductless mini-split equipment must follow the same code requirements as other condensate producing equipment due to the potential damage and health risk associated with uncontrolled condensation. Ductless mini-split units also do not have provisions for a secondary drain, or auxiliary drain pans to prevent condensation from overflowing the primary drain pan.

Ductless mini-split condensate lines are direct openings for unconditioned outside air, contaminants, insects, and other undesirable materials to enter the conditioned space and should be trapped using an inline check valve as a preventative measure.

Without this proposal, it is unclear if ductless mini-split units require water-level monitoring devices to be installed. In installations where gravity-drain condensation removal is impossible, a condensate pump must be installed that communicates with the ductless mini-split to stop the equipment if there is a failure of the condensate removal system. Power for the condensate pump should be provided from the mini-split equipment and not from a separate power source. The danger of using a separate power supply is that if the circuit that supplies power to the condensate pump fails, but the circuit providing power to the mini split equipment remains active, the pump will not operate and the equipment will produce excessive condensation without shutting down.
COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

936.0 Ductless Mini-Split Systems Installation.
936.1 General. A ductless mini-split system shall be installed in accordance with the manufacturer’s installation instructions and Section 936.2 and Section 936.3.

936.2 Water Level Monitoring Device. A water monitoring device shall be installed inside of the main drain pan of ductless mini-split systems. Such device shall shut off the equipment in the event that the primary drain becomes restricted. Devices installed in the drain line shall not be permitted.

936.3 Condensate. Where ductless mini-split equipment produces condensate, the equipment shall be provided with an inline check valve located in the drain line, or a trap. Where a ductless mini-split system is not capable of draining condensate from the unit by gravity, a condensate pump shall be installed to remove water from the unit. The condensate pump shall be powered by the same power supply that serves the equipment and shall be capable of shutting off the equipment in the event of failure of the pump to remove condensate.

COMMITTEE STATEMENT:
Section 936.2 and Section 936.3 are being deleted as they are too restrictive. The installation of a water level monitoring device may or may not be required by the manufacturer’s instructions.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:

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

936.0 Ductless Mini-Split Systems.
936.1 General. A ductless mini-split system shall be installed in accordance with the manufacturer’s installation instructions and Section 310.2 for condensate control.

SUBSTANTIATION:
The TC agreed that the UMC should address ductless mini-split systems since they are already widely used. The UMC is currently silent on this type of appliance, and this proposal requires that such appliances be installed in accordance with the manufacturers instructions. However, the proposal as approved by the TC does not go far enough to ensure that such systems do not inadvertently create moisture and mold problems due to condensation. The original proposal added language intended to require that ductless mini-split systems be installed with provisions to manage condensation and overflow. However, the TC revised Item # 053 regarding condensate control which, if approved as revised, would address the condensation problem associated with ductless mini-split systems. This modification simply directs the user to the code section that adequately addresses condensate for all types of appliances.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
936.0 Furnaces.
936.1 Solid-Fuel Furnaces. Factory built solid-fuel furnaces shall be listed or labeled in accordance with UL 391 and installed in accordance with the manufacturer’s installation instructions.

936.2 Oil-Fired Boilers. Oil-fired boiler assemblies shall be listed or labeled in accordance with UL 726 and installed in accordance with the manufacturer’s installation instructions.

936.3 Oil-Fired Central Furnaces. Oil-fired central furnaces shall be listed or labeled in accordance with UL 727 and installed in accordance with the manufacturer’s installation instructions.

936.4 Oil-Fired Wall Furnaces. Oil-fired wall furnaces shall be listed or labeled in accordance with UL 730 and installed in accordance with the manufacturer’s installation instructions.

936.5 Oil-Fired Floor Furnaces. Oil-fired floor furnaces shall be listed or labeled in accordance with UL 729 and installed in accordance with the manufacturer’s installation instructions.

936.6 Oil-Fired Air Heaters. Oil-fired air heaters shall be listed or labeled in accordance with UL 733 and installed in accordance with the manufacturer’s installation instructions.

936.7 Direct-Fired Heaters. Direct-fired heaters shall be listed or labeled in accordance with UL 733 and installed in accordance with the manufacturer’s installation instructions.

936.8 Commercial or Industrial Gas Heaters. Commercial or industrial gas heaters shall be listed or labeled in accordance with UL 795 and installed in accordance with the manufacturer’s installation instructions.

SUBSTANTIATION:
Section 936.0 through Section 936.8 will consolidate various types of furnaces within a single location. UL 391 includes a comprehensive set of construction and performance requirements that are used to evaluate and list solid fuel furnaces. UL 726 includes a comprehensive set of construction and performance requirements that are used to evaluate and list oil fired boilers. UL 727 includes a comprehensive set of construction and performance requirements that are used to evaluate and list oil fired central furnaces. UL 730 includes a comprehensive set of construction and performance requirements that are used to evaluate and list oil fired wall furnaces. UL 729 includes a comprehensive set of construction and performance requirements that are used to evaluate and list oil fired floor furnaces. UL 733 includes a comprehensive set of construction and performance requirements that are used to evaluate and list direct fired heaters. UL 795 includes a comprehensive set of construction and performance requirements that are used to evaluate and list commercial/industrial gas heaters. These standards are currently listed in Table 1701.0.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

936.0 Furnaces.
936.1 Solid-Fuel Furnaces. Factory built solid-fuel furnaces shall be listed or labeled in accordance comply with UL 391 and installed in accordance with the manufacturer’s installation instructions.

936.2 Oil-Fired Boilers. Oil-fired boiler assemblies shall be listed or labeled in accordance comply with UL 726 and installed in accordance with the manufacturer’s installation instructions.

936.3 Oil-Fired Central Furnaces. Oil-fired central furnaces shall be listed or labeled in accordance comply with UL 727 and installed in accordance with the manufacturer’s installation instructions.

936.4 Oil-Fired Wall Furnaces. Oil-fired wall furnaces shall be listed or labeled in accordance comply with UL 730 and installed in accordance with the manufacturer’s installation instructions.
936.5 **Oil-Fired Floor Furnaces.** Oil-fired floor furnaces shall be listed or labeled in accordance with UL 729 and installed in accordance with the manufacturer’s installation instructions.

936.6 **Oil-Fired Air Heaters.** Oil-fired air heaters shall be listed or labeled in accordance with UL 733 and installed in accordance with the manufacturer’s installation instructions.

936.7 **Direct-Fired Heaters.** Direct-fired heaters shall be listed or labeled in accordance with UL 733 and installed in accordance with the manufacturer’s installation instructions.

936.8 **Commercial or Industrial Gas Heaters.** Commercial or industrial gas heaters shall be listed or labeled in accordance with UL 795 and installed in accordance with the manufacturer’s installation instructions.

**COMMITTEE STATEMENT:**
There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1.

**A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**
**PUBLIC COMMENT:**
**SUBMITTER:** Phil Ribbs, PHR Consultants

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

936.0 **Furnaces.**
936.1 **904.11 Solid-Fuel Furnaces.** Factory built solid-fuel furnaces shall comply with UL 391 and installed in accordance with the manufacturer’s installation instructions.

936.2 **Oil-Fired Boilers.** Oil-fired boiler assemblies shall comply with UL 726 and installed in accordance with the manufacturer’s installation instructions.

936.3 **904.12 Oil-Fired Central Furnaces.** Oil-fired central furnaces shall comply with UL 727 and installed in accordance with the manufacturer’s installation instructions.

936.5 **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.

936.4 **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.

936.6 **Oil-Fired Air Heaters.** Oil-fired air heaters shall comply with UL 733 and installed in accordance with the manufacturer’s installation instructions.

936.7 **Direct-Fired Heaters.** Direct-fired heaters shall comply with UL 733 and installed in accordance with the manufacturer’s installation instructions.

936.8 **Commercial or Industrial Gas Heaters.** Commercial or industrial gas heaters shall comply with UL 795 and installed in accordance with the manufacturer’s installation instructions.

**SUBSTANTIATION:**
1. Section 936.1 should be relocated to Section 904.11 where all requirements pertaining to central heating furnaces are addressed.
2. Section 936.2 is unnecessary as oil-fired boilers are addressed in Chapter 10 (Section 1002.2.1), and therefore redundant. For information purposes only, Section 1002.2.1 is shown as follows: **1002.2.1 Listing & Labeling. Oil-burning boilers shall be listed and labeled in accordance with UL 726.**
3. Section 936.3 should be relocated to Section 904.12 where all requirements pertaining to central heating appliances are addressed.
4. Section 936.5 should be relocated to Section 906.13 where all requirements for floor furnaces are addressed.
5. Section 936.4 should be relocated to Section 907.4 where all requirements pertaining to wall furnaces are addressed.
6. Section 936.6 is unnecessary as UL 733 pertains to portable appliances; which are outside the scope of the UMC. The definition for “air heater” in UL 733 is as follows: “an indirect-fired vented appliance intended to supply heated air for space heating and other purposes, but not intended for permanent installation. This definition does not include central furnaces, kerosene stoves, oil-burning stoves, or unit heaters.”

7. Section 936.7 is mandating direct-fired heaters (furnaces) to be listed to UL 733. However, Section 904.2(2) permits the use of unlisted central-heating furnaces and boilers which is consistent with NFPA 54. Therefore, Section 936.7 should not be added as it creates a conflict within the code. Furthermore, Section 936.7 does not provide any direction to what type of direct-fired equipment it is applicable. For example, is it for gas, oil, or kerosene?

8. Furthermore, Section 936.7 is mandating direct-fired heaters (furnaces) to be listed to UL 795. However, Section 904.2(2) permits the use of unlisted central-heating furnaces and boilers which is consistent with NFPA 54. Furthermore, the proposed UL 795 standard creates confusion as it is not provide direction to what type of furnace it is applicable. For example, it is applicable to duct furnaces or forced-air warm furnaces? According to UL 795, it is applicable to all commercial and industrial heating equipment which includes duct furnaces, forced-warm air furnaces, and even boilers; but forced-air furnaces, duct heaters, and boilers are already addressed in Section 904.0 and Section 905.0. Lastly, mandating UL 795 will eliminate the use of other standards such as CSA Z83.8, CSA Z21.47, and CSA Z21.13.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

904.13 Commercial or Industrial Gas Heaters. Commercial or industrial gas heaters shall comply with UL 795 and installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
Section 936.8 should not be deleted as reference to UL 795 is necessary for the enforcement of commercial or industrial gas heaters. Furthermore, the section should be relocated to Section 904.13 as it is where the general requirements pertaining to furnaces are addressed.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 117)

RECOMMENDATION:
Revise text as follows:

1001.0 General.

1001.1 Applicability. The requirements of this chapter shall apply to the construction, installation, operation, repair, and alteration of all 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), as regulated by 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.
4. Containers for liquefied petroleum gases, bulk oxygen, and medical gas that are regulated by the fire code.
5. Unfired pressure vessels in Groups B, F, H, M, R, S, and U 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 that are regulated by shall comply with Chapter 11 of this code.
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.
9. Boilers within the scope of NFPA 85, including associated fuel systems shall be designed and installed in accordance with NFPA 85.

SUBSTANTIATION:
1. Section 1001.1 is being revised by adding a reference to Section 904.0 for low-pressure boilers. Section 904.0 addresses additional provisions for low-pressure boilers that might otherwise be missed by the end user.
2. The reference to Groups B, F, H, M, R, S, and U Occupancies are being revised to residential and utility occupancies since such occupancies are defined in the building code.
3. The reference to NFPA 85 is being removed since Section 1002.1 indicates that boilers shall be constructed and designed in accordance with NFPA 85.
4. All other revisions are being done to comply with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Walter Sperko, Sperko Engineering Services, Inc

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

1001.1 Applicability. The requirements of this chapter shall apply to the construction, installation, operation, repair, and alteration of all boilers and pressure vessels. Low-pressure boilers shall comply with this chapter, where applicable, 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.

SUBSTANTIATION:

1. Exception 1 is being revised to be consistent with the requirements of the plumbing code.
2. All definitions pertaining to boilers are being combined for ease of use of the code. The definition for “power boiler” is being revised to correlate with the scope of ASME BPVC Section I and Section IV. Furthermore, the definition for “power hot water boiler (high temperature water boiler)” is being deleted as it is repetitive to the definition for “power boiler.”
3. The definitions for “low-pressure hot-water-heating boiler” and “low-pressure steam-heating boiler” are being combined into one definition “low-pressure boiler” to be consistent with the terminology used in the applicability of Section 1001.1. The definition for “boiler, high pressure” is being deleted as it is a terminology not used within the code.
4. The definition for “pressure vessel” is being revised to correlate with the scope of ASME BPVC, Section VIII.
5. The definition for “water heater or hot-water-heating boiler” is being revised as it is in conflict with the definition for “hot-water-heating boiler.”
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of potable water heaters.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21     NOT RETURNED: 1 Garza
Item # 226

UMC 2015 – (1002.1):

SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 119)

RECOMMENDATION:
Revise text as follows:

1002.1 General. Pressure vessels shall be constructed and designed in accordance with the ASME Boiler & Pressure Vessel Code (BPVC). Boilers shall be constructed and designed in accordance with ASME CSD-1 and one of the following standards:
(1) ASME BPVC Section I
(2) ASME BPVC Section IV
(3) NFPA 85

SUBSTANTIATION:
Section 1002.1 is being revised to include requirements for pressure vessels. This section should address requirements for both pressure vessels and boilers. The ASME Boiler & Pressure Vessel Code (BPVC) is the standard that is widely accepted for the safe construction of pressure vessels.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

1002.1 General. Pressure vessels shall be constructed and designed in accordance with the ASME Boiler & Pressure Vessel Code (BPVC). Boilers shall be constructed, designed, and installed in accordance with ASME CSD-1 and one of the following standards:
(1) ASME BPVC Section I
(2) ASME BPVC Section IV
(3) NFPA 85
(4) ASME CSD-1

COMMITTEE STATEMENT:
Currently, boilers are required to be constructed and designed with ASME CSD-1 and one of the standards listed. However, the intent of this section is that boilers are permitted to be constructed, designed, and installed in accordance with any one of the standards including ASME CSD-1.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Walter Sperko, Sperko Engineering Services, Inc

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

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 standards:
ASME BPVC Section I  
ASME BPVC Section IV  
NFPA 85  
ASME CSD-1

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.

Except as otherwise specified, gas-fired boilers exceeding 400 000 Btu/h (117 kW) input shall comply with nationally recognized standards approved by the Authority Having Jurisdiction.

The Authority Having Jurisdiction shall have the authority to approve solid-fuel-fired boilers that comply with the safety requirements for automatic gas- or oil-fired boilers.

SUBSTANTIATION:
1. ASME CSD-1 should be relocated to Section 1003.2.1 (Automatic Boilers) as it only applies to controls and devices for automatic boilers. Furthermore, the text “Except as otherwise specified, gas-fired boilers exceeding 400 000 Btu/h (117 kW) input shall comply with nationally recognized standards approved by the Authority Having Jurisdiction” is being deleted as ASME CSD-1 and Table 1003.2.1 also address controls and limit devices for automatic boilers that exceed 400 000 Btu/h.

2. The text “standard” in Section 1002.1 (General) should be removed as it is redundant to the title for Section 1002.0 (Standards).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (deleting an exception in Section 1003.2.1) not published in the ROP as part of the proposal being commented on. The committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”
1005.1 General. An expansion tank shall be installed in a hot-water-heating systems as a means for controlling increased pressure caused by thermal expansion. Expansion tanks shall be provided with an air of the closed or open type expansion tank and securely fastened to the structure. Tanks shall be rated for the pressure of the system. Supports shall be approved to carry 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 as to prevent freezing under normal operating conditions.

1005.2 Systems with Open Type Expansion Tanks. Systems equipped with an open expansion tank to satisfy thermal water expansion shall be provided with an indoor overflow from the upper portion of the expansion tank in addition to an open vent. The indoor overflow shall be carried within the building to a plumbing fixture or to the basement. 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.

1005.3 Closed-Type Systems. Systems of the 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 or above 30 pounds-force per square inch (psig) (207 kPa) shall be constructed in accordance with nationally recognized standards approved by the Authority Having Jurisdiction. Provisions shall be made for draining the tank without emptying the system, except for pressurized tanks.

1005.4 Minimum Capacity of Closed-Type Tank. The minimum capacity of the closed-type expansion tank shall be permitted to be determined from Table 1005.4(1) and Table 1005.4(2) or from the following formula:

\[
C = \frac{1}{\gamma} \cdot \frac{V}{h}
\]

where:
- \(C\) is the capacity of the tank
- \(V\) is the volume of the system
- \(h\) is the height of the system
- \(\gamma\) is the density of water

(remaining text unchanged)

SUBSTANTIATION:

1. Section 1005.1 is being revised to correlate with Section 604.1 of the Uniform Solar Energy Code (USEC). For informational purposes only, Section 604.1 of the USEC is shown as follows: 604.1 Where Required. An expansion tank shall be installed in a solar thermal system where a pressure reducing valve, backflow prevention device, check valve or other device is installed on a water supply system utilizing storage or tankless water heating equipment 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 sized based on 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 the connecting piping. Solar thermal systems incorporating hot water tanks or fluid relief columns shall be installed as to prevent freezing under normal operating conditions.

2. Section 1005.2 is being revised to correlate with Section 604.2 of the Uniform Solar Energy Code (USEC). For informational purposes only, Section 604.2 of the USEC is shown as follows: 604.2 Systems with Open Type Expansion Tanks. Open type expansion tanks shall be located not less than 3 feet (914 mm) above the highest point of the system. Such tanks shall be sized based on the capacity of the system. An overflow with a diameter of not less than one-half the size of the water supply or not less than 1 inch (25 mm) in diameter shall be installed at the top of the tank. The overflow shall discharge through an air gap into the drainage system.

3. Section 1005.3 is being revised to correlate with Section 604.3 of the Uniform Solar Energy Code (USEC). For informational purposes only, Section 604.3 of the USEC is shown as follows: 604.3 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 or above 30 pounds-force per square inch (psi) (207 kPa) shall be constructed in accordance with nationally recognized
standards and the Authority Having Jurisdiction. Provisions shall be made for draining the tank without emptying the system, except for pressurized tanks.

4. Section 1005.4 is being revised to correlate the UMC with the 2012 Uniform Solar Energy Code (USEC) pertaining to the minimum capacity of closed-type tanks. For informational purposes only, Section 604.4 of the USEC is shown as follows: 604.4 Minimum Capacity of Closed-Type Tank. The minimum capacity of a closed-type expansion tank shall be in accordance with Table 604.4(1) and Table 604.4(2) or from the following formula:

**COMMITTEE ACTION:** Accept as Submitted

**A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**

**PUBLIC COMMENT:**

**SUBMITTER:** Walter Sperko, Sperko Engineering Services, Inc

**RECOMMENDATION:**

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

1005.3 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 or above more than 30 pounds-force per square inch (psi) (207 kPa) shall comply with be constructed in accordance with nationally recognized standards ASME BPVC Section VIII and the Authority Having Jurisdiction. Provisions shall be made for draining the tank without emptying the system, except for pressurized tanks with membranes such as diaphragm-type tanks.

1005.4 Minimum Capacity of Closed-Type Tank. The minimum capacity for a gravity-type hot water system expansion tank shall be in accordance with Table 1005.4(1). The minimum capacity of the closed type for a forced-type hot water system expansion tank shall be in accordance with Table 1005.4(1) and Table 1005.4(2), or from the following formula: Equation 1005.4. Equation 1005.4 shall not be used for diaphragm-type expansion tanks.

### TABLE 1005.4(1)

<table>
<thead>
<tr>
<th>INSTALLED EXPANSION EQUIVALENT DIRECT RADIATION&lt;sup&gt;2&lt;/sup&gt;</th>
<th>TANK CAPACITY&lt;sup&gt;1&lt;/sup&gt; (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 350</td>
<td>18</td>
</tr>
<tr>
<td>Up to 450</td>
<td>21</td>
</tr>
<tr>
<td>Up to 650</td>
<td>24</td>
</tr>
<tr>
<td>Up to 900</td>
<td>30</td>
</tr>
<tr>
<td>Up to 1100</td>
<td>35</td>
</tr>
<tr>
<td>Up to 1400</td>
<td>40</td>
</tr>
<tr>
<td>Up to 1600</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 1800</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 2000</td>
<td>2 to 35</td>
</tr>
<tr>
<td>Up to 2400</td>
<td>2 to 40</td>
</tr>
</tbody>
</table>

For SI units: 1 gallon = 3.785 L, 1 square foot = 0.0929 m²

**Notes:**

1. Based on a two-pipe system with an average operating water temperature of 170°F (77°C), using cast-iron column radiation with a heat emission rate of 150 British thermal units per square foot hour [Btu/(ft²•h)] (473 W/m²) equivalent direct radiation.

2. For systems 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.
Equation 1005.4

\[ V_t = \frac{(0.00041t - 0.0466)V_s}{\left( \frac{P_a}{P_f} - \frac{P_a}{P_o} \right)} \]

TABLE 1005.4(2)

EXPANSION TANK CAPACITIES FOR FORCED HOT WATER SYSTEMS¹

<table>
<thead>
<tr>
<th>SYSTEM VOLUME¹ (gallons)</th>
<th>TANK CAPACITY DIAPHRAGM TYPE (gallons)</th>
<th>TANK CAPACITY NONDIAPHRAGM TYPE (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>200</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>300</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>400</td>
<td>33</td>
<td>60</td>
</tr>
<tr>
<td>500</td>
<td>42</td>
<td>75</td>
</tr>
<tr>
<td>1000</td>
<td>83</td>
<td>150</td>
</tr>
<tr>
<td>2000</td>
<td>165</td>
<td>300</td>
</tr>
</tbody>
</table>

SUBSTANTIATION:

1. Section 1005.3 should be modified as ASME BPVC Section VIII is the nationally recognized standard for expansion tanks exceeding 30 psi. Furthermore, the text “pressurized” should be modified to “nondiaphragm-type” to be consistent with the modification made to Table 1005.4(2) and with language used in Section 1209.2. It should be noted that ASME BPVC Section IV uses the term “prepressurized” when referring to a diaphragm-type tank and “nonpressurized” when referring to a nondiaphragm-type tanks. However, the terminologies used throughout the UMC are “diaphragm-type” and “nondiaphragm-type,” and therefore the terminology used in ASME was not used to avoid any confusion.

2. Section 1005.4 is being modified for clarity. Furthermore, the text “Equation 1005.4 shall not be used for diaphragm-type expansion tanks” is being added to clarify to the end user that Equation 1005.4 only applies to nondiaphragm expansion tanks. Diaphragm-type expansion tanks are pre-engineered which are sized in accordance with the manufacturers of the expansion tank or boiler.

3. Table 1005.4(2) should be modified to correlate with the expansion tank capacity table found in ASME BPVC Section IV. The UMC addresses requirements for diaphragm type tanks, and therefore tank capacities are required in the code. Furthermore, such modification is necessary so that it can be applicable with Section 1209.2.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

TAYLOR: I am voting negative for the following reasons:

- Expansion tanks are included in both Chapter 10 and Chapter 12. They should be in Chapter 12 since they are required for all closed systems not just heating systems. So the sections in Chapter 10 are deleted.
• There is no need to distinguish between open (vented) and closed tanks. Their requirements should be merged to reduce repetition.
• The sizing requirements for diaphragm tanks and other types are exactly the same,
• Both open and closed tanks require a means to drain the tank for service. For closed tanks, this is needed to adjust pre-charge in the case where it is not set at the factory.
• The equations and tables are in fact very wrong, possibly causing tanks to be undersized by a factor of 10. The correct equations are in the ASHRAE Handbook and also this article which I authored: http://www.taylor-engineering.com/downloads/articles/ASHRAE%20Journal%20-%20Understanding%20Expansion%20Tanks%20-%20Taylor.pdf. The equations are actually not all that useful without knowing how to determine the variables used such as precharge and maximum pressure. I think they are too complex and unenforceable to be in the code. Sizing tanks is actually fairly complex and should be left to the engineer of record. The system is protected with relief valves so there is not a safety issue if tanks are undersized.
SUBMITTER: Dave Levanger  
Chair, Technical Correlating Committee (TCC) (see TCC Report Items # 187, 188)

RECOMMENDATION:
Revise text as follows:

1006.0 Safety or Relief Valve Discharge.

1006.1 General. The relief valve discharge pipe shall be of approved material that is rated for the temperature of the system. The discharge pipe shall be of the same diameter as the safety or relief valve outlet, discharge 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. The discharge pipe from relief valves shall be within 18 inches (457 mm) of the floor or to an open receptacle, and Where the operating temperature is in excess of exceeds 212°F (100°C), shall be equipped installed with a splash shield or centrifugal separator. Where the discharge from safety valves would result in a is capable of being hazardous, discharge of steam inside the boiler room, such discharge shall be extended discharged to the outside the boiler room. No valve shall be placed between the safety or relief valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. Discharges from relief valves on industrial boilers shall be discharged to an approved location.

1006.2 Vacuum Relief Valve. Hot-water heating systems that are subjected to a vacuum while in operation or during shut-down 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.

220.0
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 predetermine value.

224.0
Vacuum. A pressure less than that exerted by the atmosphere.

SUBSTANTIATION:
1. Section 1006.1 is being revised to correlate with Section 315.1 of the Uniform Solar Energy Code (USEC) in regards to the discharge requirements for pressure relief valves. For informational purposes only, Section 315.1 of the USEC is shown as follows: 315.1 Pressure Relief Valves. Solar energy system components containing pressurized fluids shall be protected against pressures exceeding design limitations with a pressure relief valve. Each section of the system in which excessive pressures are capable of developing shall have a relief device located so that a section cannot be isolated from a relief device. Valves shall not be located on either side of a relief valve connection. The relief valve discharge pipe shall be of approved material that is rated for the temperature of the system. The discharge pipe shall be the same diameter as the relief valve outlet, discharge 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) nor less than 6 inches (152 mm) above the ground and pointing downward. The 18 inch requirement is being deleted since it is in conflict with the 6 inch requirement that was added to Section 1006.1 due to the correlation between the UMC and the USEC. All other revisions were done to comply with the IAPMO Manual of Style.

2. Section 1006.2 is being added to correlate with Section 315.2 of the Uniform Solar Energy Code (USEC). Furthermore, the definitions for “relief valve, vacuum” and “vacuum” are being added to correlate with the USEC since the terms are used in the proposed Section 1006.2 without being defined. The proposed definition assists the end user in applying and enforcing this term. For informational purposes only, Section 315.2 and the definitions of “relief valve, vacuum” and “vacuum” of the USEC are shown as follows: 315.2 Vacuum Relief Valves. The solar energy system components that are subjected to a vacuum while in operation or during shutdown shall be protected with vacuum relief valves. Where the piping configuration, equipment location, and valve outlets are located below the storage tank elevation the system shall be equipped with a vacuum relief valve at the highest point.
220.0
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.

224.0
Vacuum. A pressure less than that exerted by the atmosphere.

3. Vacuum relief valves should be installed in hot-water systems that are subjected to a vacuum. Vacuum relief are installed where a method of freeze protection is employed that drains the liquid from components exposed to freezing, in which the draining will cause a significant partial vacuum in the system. They are typically mounted to pipe that connects to the vapor space (space within the boiler that is above the liquid surface). The pressure in the vapor space increases or decreases as liquid is pumped into or out of the boiler. Furthermore, atmospheric temperature changes can cause an expansion or contraction of the vapors in this space, again resulting in pressure increases or decreases. Requiring a vacuum relief valve where a system is subjected to a vacuum will ensure that the space is always maintained within the safe range of its pressure and vacuum operating design limits.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Tim Ross, Ross Distributing Inc.

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

1006.1 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.

1006.2 Discharge Piping. The relief valve 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 downward.

2) Materials shall be rated at not less than the temperature of the system and approved for such use.

3) Discharge pipe shall discharge 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.

1006.3 Splash Shield. Where the operating temperature exceeds 212°F (100°C), shall be installed with a splash shield or centrifugal separator.

1006.4 Hazardous Discharge. Where the discharge from safety valves is capable of being hazardous, discharge of steam inside the boiler room, such discharge shall be discharged to the outside the boiler room. No valve shall be placed between the safety or relief valve and the boiler, on the discharge pipe between the safety valve and the atmosphere. Discharges from relief valves on industrial boilers shall be discharged to an approved location.

(renumber remaining sections)

1005.2 Temperature, Pressure, and Vacuum Relief Devices. Temperature, pressure, and vacuum relief devices or combination thereof, and automatic gas shutoff devices shall be installed in accordance with the manufacturer’s installation instructions. A shutoff valve shall not be placed between the relief valve and the pressure vessel or boiler or on the discharge pipe between such valves and the atmosphere. The hourly British thermal units (Btu) (kW•h) discharge capacity or the rated steam relief capacity of the device shall be not less than the input rating of the pressure vessel or boiler. [NFPA 54:10.28.5]
1206.3 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall have no valves, obstructions, or means of isolation and be provided with the following:

1. 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 downwards.

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 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 terminate to the floor, waste receptor, or to the outdoors. The end of the pipe shall not terminate more 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.

SUBSTANTIATION:
Section 1006.1 is being revised to correlate with the Section 1206.3 and the 2015 Uniform Solar Energy and Hydronics Code (USEHC). Furthermore, Section 1206.3 is being revised to correlate with the modifications made by the USEHC Technical Committee. Section 1005.2 is being deleted as similar requirements are already addressed within Section 1006.1 and Section 1206.3, therefore redundant. Lastly, the provisions pertaining to splash guards and hazardous discharge that are addressed within Section 1006.1 are being relocated to their own Sections (Section 1006.3 and Section 1006.4).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
CABOT: While this comment addresses sections not included as part of this proposal (Item # 231), those sections were out for public review under other proposals and therefore does not violate IAPMO/ANSI procedures.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 231 (Public Comment 1) for “discharge piping” and UPC Item # 207.03 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

1006.2 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 downwards.

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.

1206.3 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall have no valves, obstructions, or means of isolation and be provided with the following:

1. 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 downwards.
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.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revision to Section 1006.2 and Section 1206.3 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 207.03.

The Committee statement provided by the UPC TC for accepting the public comment Item # 207.03 as amended is as follows: “The proposed modification will clarify the intent of the section in regards to the discharge pipe that should run independently and prohibits relief valve discharge into a water heater pan.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on Section 1006.2 and Section 1206.3 in regards to discharge piping.

PUBLIC COMMENT 2:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

1006.1 General. The relief valve discharge pipe shall be of approved material that is rated for the temperature of the system. The discharge pipe shall be of the same diameter as the safety or relief valve outlet, discharge 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. Where the operating temperature exceeds 212°F (100°C), the discharge pipe shall be installed with a splash shield or centrifugal separator. Where the discharge from a safety valve is capable of being hazardous, discharge of steam inside the boiler room, such discharge shall be discharged to the outside of the boiler room. No valve shall be placed between the safety or relief valve and the boiler, on the discharge pipe between the safety valve, and the atmosphere. Discharges from relief valves on industrial boilers shall be discharged to an approved location. No part of such discharge pipe shall be trapped or subject to freezing.

SUBSTANTIATION:
Section 1006.1 is being modified to correlate with Section 1206.3(5) in regards to the discharge pipe from a relief valve. Such language is necessary to avoid the discharge pipe from being clogged from ice blockages.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 130)

RECOMMENDATION:
Revise text as follows:

1102.0 Refrigeration Systems.
1102.1 General. Except as modified by this code, refrigeration systems shall comply with this chapter and ASHRAE 15. In addition, ammonia refrigeration systems shall comply with IIAR 2.
1102.2 Refrigerants. The refrigerant used shall be of a type listed in Table 1102.2 or as classified under Section 1103.0 as approved in accordance with ASHRAE 34 where approved by the Authority Having Jurisdiction.

SUBSTANTIATION:
1. Section 1102.1 is being revised for clarity.
2. In Section 1102.2, reference to ASHRAE 34 is being made to indicate to the end user that the refrigerant used shall be of a type listed in Table 1102.2 or in ASHRAE 34. Reference to Section 1103.0 is being removed since this section deals with the use of refrigerant and not the classification of refrigerants.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

1102.1 General. Refrigeration systems shall comply with this chapter and ASHRAE 15.

Exception: Ammonia refrigeration systems shall comply with IIAR 2.

COMMITTEE STATEMENT:
Section 1102.1 was modified for clarity and to provide guidance on the applicable standard for ammonia refrigeration systems.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:

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

1104.3.3 Lower Flammability Limit. Where the quantity of a Group A2, B2, A3 or B3 refrigerant, other than ammonia, in an independent circuit will exceed 25 percent of the lower flammability limit where released to the surrounding room, one of the following shall be provided:

(1) - (2) (remaining text unchanged)

1104.4 All Occupancies. The quantity of Group A2, B2, A3, and B3 refrigerants, other than ammonia, shall not exceed 1100 pounds (498.9 kg) unless approved by the Authority Having Jurisdiction. [ASHRAE 15.7.5.1.1]

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) Ammonia-water absorption unit systems installed outdoors, provided that the quantity of refrigerant in a single system does not exceed Table 1102.2 amounts and the discharge is shielded and dispersed.

1107.2 Refrigeration Machinery Rooms. Refrigeration machinery rooms shall be provided with dedicated mechanical exhaust systems. The exhaust systems shall have the capacity to provide emergency purge of escaping refrigerant at a rate of 30 air changes per hour (ACH) for ammonia, or for other refrigerants as determined in accordance with Equation 1107.2:

1114.1 General. Systems containing other than Group A1 or B1 refrigerants shall discharge to atmosphere through an approved flaring device.

Exceptions:

(1) Ammonia absorption systems serving a single dwelling unit.

(2) (remaining text unchanged)

(3) (remaining text unchanged)

### TABLE 1102.2

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME</th>
<th>SAFETY GROUP</th>
<th>OEL (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-717</td>
<td>NH₃</td>
<td>Ammonia</td>
<td>B₂</td>
<td>25</td>
<td>0.014</td>
</tr>
</tbody>
</table>

**SUBSTANTIATION:**

Under Item # 242, the Committee amended Chapter 11 to exclude ammonia refrigeration systems and simply reference IIAR 2 as a basis of design and installation. IIAR 2-2014 is being revised to serve as a stand-alone design, installation, and safety standard for ammonia refrigeration systems as of the 2014 edition.

Action on several other proposals deleted references to ammonia systems based on Item # 242, but there were several remaining references in Chapter 11 to ammonia systems that need to be editorially deleted, as recommended by this public comment to fully execute the intended change and entirely remove specific exceptions for ammonia refrigeration systems from the UMC.

Note: If this comment is not accepted (perhaps if the deferral to IIAR 2 under Item # 242 is reversed in the public comment process), the committee will need to reinstate all ammonia exceptions and requirements that were deleted in the ROP process so that treatment of ammonia systems under the UMC remains complete in the 2015 edition.

**COMMITTEE ACTION:** Reject the public comment

**COMMITTEE STATEMENT:**

The public comment removes language that is necessary for the enforcement of ammonia systems. Furthermore, the modifications to Section 1104.3.3 and Section 1104.4 do not correlate with ASHRAE 15.

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:** AFFIRMATIVE: 19  NEGATIVE: 2  NOT RETURNED: 1 Garza
EXPLANATION OF NEGATIVE:

CARROLL: The Committee’s reconsideration and final action on this item has unfortunately created numerous internal conflicts and deficiencies in Chapter 11 of the 2015 UMC with respect to treatment of ammonia refrigeration systems. The Committee created an exception to compliance with Chapter 11 for ammonia refrigeration, deferring instead to the ANSI standard governing ammonia refrigeration, which is IIAR 2. To accomplish this change, the reference to IIAR 2 in UMC Section 1102.1 was reconfigured such that IIAR 2 will now be an exception to Chapter 11, rather an additional reference like ASHRAE 15.

Several other proposals were then modified based on the assumption that ammonia refrigeration systems would no longer specifically be regulated by the UMC, including:

- Item 258: the reference to IIAR 2 allowing outdoor ammonia machinery rooms was dropped.
- Item 264: the reference to triggering emergency ventilation for ammonia at 1,000 ppm in Section 1107.6 was dropped.
- Item 291: Section 1120, which provides an allowance for water diffusion rather than flaring, was dropped, along with the text that referenced this section (found in Section 1114.1, Exception 1 of the ROP UMC preprint).

In addition to making the changes above the International Institute of Ammonia Refrigeration, publisher of IIAR 2, to submit a public comment to delete remaining references to ammonia refrigeration in Chapter 11 to complete the intended change. This was largely accomplished by IIAR’s public comment to Item 242. The Committee approved this comment on the first day of the ROC meeting. However, on the second day of the ROC meeting, after the proponent of the comment had left the meeting, the Committee reconsidered the comment and reversed its decision, which is leaving the UMC in the middle of “does” and “does not” regulate ammonia refrigeration.

On the “does” side, disapproving the public comment to Item 242 causes several references to R717 and ammonia to be retained in the 2015 code, suggesting that ammonia is covered. On the “does not” side, the exception to Section 1102.1, approved as part of the ROP action on Item 242, altogether exempts ammonia from Chapter 11 (and with the items noted in the bullet list above missing, the UMC’s provisions will be inadequate to properly regulate ammonia).

Unfortunately, the problems that resulted from rejection of the public comment to Item 242 may be beyond what can be reasonably fixed by the membership when they review the UMC for final adoption. Assuming that is the case, it may be necessary to consider a TIA to fix this or risk creating significant use and enforcement issues in jurisdictions that adopt the 2015 UMC.

TAYLOR: We need to completely take ammonia out of this Chapter since we already reference IIAR. Otherwise, conflicts are inevitable.
Item # 244  
UMC 2015 – (1102.1, Table 1701.0):  

SUBMITTER: Jeffrey M. Shapiro  

RECOMMENDATION:  
Revise text as follows:  

1102.1 General. Except as modified by this code, refrigeration systems shall comply with ASHRAE 15. In addition, ammonia refrigeration systems shall comply with IIAR 2 and IIAR 3.  

| TABLE 1701.0  
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>IIAR 3-2012*</td>
<td>Ammonia Refrigeration Valves</td>
<td>Ammonia Refrigeration Systems</td>
<td>1102.1</td>
</tr>
</tbody>
</table>

Note: IIAR 3 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations governing Committee Projects.

(subparts of table not shown remain unchanged)  

SUBSTANTIATION:  
The International Institute of Ammonia Refrigeration is completing a suite of standards to prescribe regulations for the safe design, installation, operation, maintenance, inspection and decommissioning of ammonia refrigeration systems. All of these documents will be ANSI standards. As the leading organization representing the interests of the ammonia refrigeration industry, IIAR believes that it is essential for facilities with ammonia refrigeration systems to follow the requirements in these standards, which are being written as enforceable documents, as a basis of providing for the safety of these facilities as well as surrounding communities.

The standards that relate to design, equipment, installation and startup/commissioning are being proposed for inclusion in the UMC, beginning with IIAR 3. IIAR 4 and IIAR 5, which are pending completion of the ANSI process, will be proposed to be added to Section 1102.1 during the comment stage of the UMC. IIAR’s other standards that relate to maintenance, inspection, operation and decommissioning have been proposed to NFPA 1-Uniform Fire Code.

COMMITTEE ACTION: Reject  

COMMITTEE STATEMENT:  
This proposal was rejected in favor of Item # 242 which clarifies that IIAR 2 is the applicable standard for ammonia refrigeration systems. Furthermore, the reference to IIAR 3 is not necessary as IIAR 2 makes reference to IIAR 3.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.  

PUBLIC COMMENT:  

RECOMMENDATION:  
Request to replace the code change proposal by this public comment.
1102.1 General. Refrigeration systems shall comply with this chapter and ASHRAE 15. 

Exception: Ammonia refrigeration systems shall comply with IIAR 2, IIAR 3, IIAR 4, and IIAR 5.

<table>
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</tr>
</thead>
<tbody>
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<td>STANDARD NUMBER</td>
<td>STANDARD TITLE</td>
</tr>
<tr>
<td>IIAR 3-2012*</td>
<td>Ammonia Refrigeration Valves</td>
</tr>
<tr>
<td>IIAR 4-2014*</td>
<td>Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems</td>
</tr>
<tr>
<td>IIAR 5-2013*</td>
<td>Start-Up and Commissioning of Closed Circuit Ammonia Refrigeration Systems</td>
</tr>
</tbody>
</table>

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

Note: IIAR 2 and IIAR 4 are working drafts and were not completed at the time of this monograph.

SUBSTANTIATION:
Section 1102.1 is being modified as IIAR 2, IIAR 3, IIAR 4, and IIAR 5 are the industry standards used for design, equipment, installation and startup/commissioning of ammonia refrigeration systems. The reference to IIAR 2 is being updated, and the references to IIAR 3, IIAR 4, and IIAR 5 are new. Cumulatively, these documents encompass the necessary requirements for design, equipment selection, installation, start-up and commissioning of ammonia refrigeration systems.

COMMITTEE ACTION: Accept the public comment as amended

Amend comment as follows:

1102.1 General. Refrigeration systems shall comply with this chapter and ASHRAE 15. 

Exception: Ammonia refrigeration systems shall comply with IIAR 2, IIAR 3, IIAR 4, and IIAR 5.

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</tr>
<tr>
<td>IIAR 4-2014*</td>
<td>Installation of Closed-Circuit Ammonia Mechanical Refrigerating Systems</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

COMMITTEE STATEMENT:
The updated standard to IIAR 2-2014 and standard IIAR 4 should be deleted as they are incomplete standards and have not been published.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 139)

RECOMMENDATION:
Add new text as follows:

**1104.4 Higher Flammability Refrigerants.** The use of Group A3 and B3 refrigerants shall be approved by the Authority Having Jurisdiction.  

**Exceptions:**
1. Laboratories with more than 100 square feet (9.29 m²) of space per occupant.
2. Industrial occupancies.
3. Listed portable-unit systems containing not more than 0.331 pounds (0.150 kg) of Group A3 refrigerant where the equipment is installed in accordance with the listing and the manufacturer’s installation instructions. [ASHRAE 15:7.5.3]

SUBSTANTIATION:
Section 1104.4 will require the use of Group A3 and B3 refrigerants to be approved by the AHJ since Group A3 and B3 refrigerants are of higher flammability and higher toxicity compared to other refrigerant groups. Exception 1 recognizes that laboratories conduct specialized tasks with specialized safety procedures. Exception 2 recognizes that industrial occupancies have a lower density compared with other occupancies and is only accessible to specialized personnel. Exception 3 recognizes that portable units containing a quantity of 0.331 pounds will not pose a threat to the occupants where installed in accordance with the manufacturer’s installation instructions. The requirements in Section 1104.6 will correlate with the requirements of ASHRAE 15-2010.

COMMITTEE ACTION: Accept as Amended by the TC  
Amend proposal as follows:

**1104.4 Higher Flammability Refrigerants.** The use of 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 occupant.
2. Industrial occupancies.
3. Listed portable-unit systems containing not more than 0.331 pounds (0.150 kg) of Group A3 refrigerant where the equipment is installed in accordance with the listing and the manufacturer’s installation instructions. [ASHRAE 15:7.5.3]

COMMITTEE STATEMENT:
The modification will correlate with the language used in ASHRAE 15.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.  
PUBLIC COMMENT:  
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)  

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

**1103.2 Classification of Refrigeration Systems.** Refrigeration systems shall be classified according to the degree of probability that a leakage of refrigerant capable of entering will enter an normally occupied 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 is capable of entering 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 greater than the secondary coolant. [ASHRAE 15:5.2.1]

1104.4 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 occupant person.
(2) Industrial occupancies.
(3) Listed portable-unit systems containing not more than 0.331 pounds (0.150 kg) of Group A3 refrigerant, where provided that the equipment is installed in accordance with the listing and the manufacturer’s installation instructions. [ASHRAE 15:7.5.3]

1104.4 All Occupancies Flammable Refrigerants. The quantity total of Group A2, B2, A3, and B3 refrigerants, other than R-717 (ammonia), shall not exceed 1100 pounds (498.9 kg) unless approved without approval by the Authority Having Jurisdiction. [ASHRAE 15:7.5.1.1]

1104.7 Changing Refrigerants. A change in the type of refrigerant in a system shall not be made without notifying the Authority Having Jurisdiction, the user, and due observance of safety requirements. The refrigerant being considered shall be approved evaluated for suitability. [ASHRAE 15:5.3]

1107.3 Natural Ventilation. Natural ventilation shall be permitted where the machinery room a refrigerating system is installed located outdoors more than 20 feet (6096 mm) from a building's opening and is enclosed by a penthouse, lean-to, or other structure, natural or mechanical ventilation shall be provided. The requirements for such natural ventilation shall be in accordance with the following:

(a) The free-aperture cross-sectional free opening area for the ventilation of a machinery room shall be not less than as determined in accordance with Equation 1107.3. The location of the gravity ventilation openings shall be based on the relative density of the refrigerant to air.

\[ F = \sqrt{G} \]

(Equation 1107.3)

Where:
\[ F = \text{The free opening area, square feet.} \]
\[ G = \text{The Total mass of refrigerant in the largest system, any part of which is located in the machinery room, pounds.} \]

For SI units: 1 square foot = 0.0929 m², 1 pound = 0.453 kg

(b) The location of the gravity ventilation openings shall be based on the relative density of the refrigerant to air. [ASHRAE 15:18.11.5(a), (b)]

1109.3 Penetration of Piping. Refrigerant piping shall be permitted to not penetrate floors, ceilings, or roofs where installed in accordance with the following:

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 1102.2 for the smallest occupied space through which the refrigerant piping passes.
(5) In other than nonindustrial occupancies and where the refrigerant concentration exceeds that listed in Table 1102.2 for the smallest occupied space, penetrations that connect separate pieces of equipment that are in accordance with one of the following:

242
(a) Enclosed by an approved gastight, fire-resistant 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]

1109.4.1 Protection from Mechanical Damage. Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be located in an elevator, dumbwaiter, or other a shaft containing a moving objects, 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]

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 be 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 having 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 be 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 and outlet 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 a condenser where more than one condenser is used in parallel in the systems.

Exceptions:

1. Where the receiver is an integral part of the condenser or condensing unit, it shall not require a stop valve at the inlet.
2. Systems having that have a refrigerant pumpout function capable of storing the refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant. [ASHRAE 15:9.12.5]

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 high-side 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 high-side 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 be permitted to be more than the design pressure of the high-side of the system, provided the pressure-relief device is located in the low-side, subject to low-side pressure, and there is a permanent (unvalved) relief path between the high-side and the low-side of the system. [ASHRAE 15:9.9.2]

1111.3 Connection. Pressure-limiting devices shall be connected between the pressure-imposing element and the stop valve on the discharge side. There shall be no without intervening stop valves in the line leading to the pressure-limiting device. [ASHRAE 15:9.9.3]

1112.4 Evaporators. Evaporators located downstream, or upstream within 18 inches (457 mm), of a heating coil shall be fitted with a pressure-relief device discharging outside the building in accordance with the requirements of Section 1112.10.

Exceptions:

1. Relief valves shall not be required on heating coils that are capable of producing a temperature that will result in the saturation pressure of the refrigerant being less than the design pressure.
(2) A relief valve shall not be required on self-contained or unit systems where the volume of the low-side 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.

\[
\frac{V_1}{W_1 - \left( \frac{V_2 - V_1}{V_{gt}} \right)} > V_{gc}
\]

(Equation 1112.4)

Where:
- \( V_1 \) = Low-side volume, cubic foot.
- \( V_2 \) = Total volume of system, cubic foot.
- \( W_1 \) = Total weight of refrigerant in system, pounds.
- \( V_{gt} \) = Specific volume of refrigerant vapor at 110°F, cubic feet per pound.
- \( V_{gc} \) = Specific volume at critical temperature and pressure, cubic feet per pound. [ASHRAE 15:9.4.4]

4113.31112.7 Location. (remaining text unchanged)

(renumber remaining sections)

1112.8.1 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 need not be larger, but shall not be smaller, less than the relief-valve inlet. [ASHRAE 15:9.5.2]

1112.10 Discharge Location. For systems in which one or more of the following apply, pressure-relief devices and fusible plugs shall discharge to the outdoor atmosphere at a location not less than 15 feet (4572 mm) above the adjoining ground level, and not less than 20 feet (6096 mm) from a window, ventilation opening, or exit of an opening into a building for the following systems:

(1) Systems containing a Group A3 or B3 refrigerant.
(2) Systems containing more than 6.6 pounds (2.99 kg) of a Group A2, B1, or B2 refrigerant.
(3) Systems containing more than 110 pounds (49.9 kg) of a Group A1 refrigerant.
(4) Systems where a machinery room is required.

The discharge shall be terminated in a manner that will prevent both the discharged refrigerant from being sprayed directly on personnel in the vicinity and foreign material or debris from entering the discharge piping. Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging the pipe where in the event the fusible plug or rupture member functions. Exception: Where systems using R-718 (water) as the refrigerant, discharge are permitted to discharge to a floor drain shall be permitted, where in accordance with the following:

(1) The pressure relief device set pressure does not exceed 15 psig (103 kPa).
(2) The floor drain is sized to handle not less than the flow rate from a single broken tube in a refrigerant-containing heat exchanger.
(3) The working fluid, corrosion inhibitor, and other additives used in the this type of refrigeration system shall be is approved by the Authority Having Jurisdiction to be discharged to the sewer system, or a catch tank shall be installed, that is sized to handle the expected discharge, is installed and shall be equipped with a normally closed drain valve and an overflow line to the drain. [ASHRAE 15:9.7.8]

1113.5 Discharge Capacity. The minimum required discharge capacity of the pressure-relief devices or fusible plug for a pressure vessel shall be not less than the capacity determined in accordance with Equation 1113.5:

Where one pressure-relief device or fusible plug is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel.
\[ C = fDL \]  
(Equation 1113.5)

Where:

\( C \) = Minimum required discharge capacity of the relief device expressed as mass flow of air, in pounds of air per minute.

\( D \) = Outside diameter of vessel, feet.

\( L \) = Length of vessel, feet.

\( f \) = 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 pressure vessel, the required capacity shall be the sum of the capacity required for every pressure vessel. [ASHRAE 15:9.7.5]

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 outdoors atmosphere. Dual pressure-relief valves shall be installed with a three-way valve to allow testing or repair. Where dual pressure relief valves are used, the valve shall comply with Section 1113.5.

Exception: A single relief 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 low-side 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 and pressure vessels in the system are separately protected in accordance with Section 1113.1, Exception 2. [ASHRAE 15:9.7.2.3]

1115.4 Marking of Pressure-Relief Devices. Pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or by an approved assembler in accordance with ASME BPVC Section VIII. Pressure-relief valves 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 permitted to be marked by the manufacturer with the pressure-setting capacity. [ASHRAE 15:9.6.1]

1115.4.2 Fusible Plugs. Fusible plugs shall be marked with the melting temperatures in °F (°C) to show compliance with this chapter. [ASHRAE 15:9.6.3]

SUBSTANTIATION:
Sections 1103.2, 1103.2.1, 1103.3, 1104.4, 1104.7, 1107.3, 1109.3, 1109.4.1, 1110.1, 1110.2, 1111.2, 1111.3, 1112.4, 1112.8.1, 1112.10, 1113.5, 1113.6, 1115.4, and 1115.4.2 are being revised to correlate with ASHRAE 15-2010 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). Furthermore, Section 1117.3 should be relocated to Section 1112.7 as it is where pressure-relief devices are addressed and to correlate with ASHRAE 15-2013.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
CABOT: While the comment addresses sections not included in the proposal (Item # 246), other proposals out for public review did include many of these sections. Where the comment addresses section not part of any other proposal, the subject topic was raised (in other proposals) and therefore a comment is appropriate.
1105.2 Volume of Occupied Space Refrigerant Concentration Limit. The quantity concentration of refrigerant in a single, complete discharge of an independent circuit of a high-probability system shall not exceed the amounts shown in Table 1102.2, based on the volume of the occupied space. The volume of the smallest enclosed, occupied space shall be used to determine the permissible quantity of refrigerant in a system that is located in, serves, or passes through such space. In accordance to this section, occupied space shall include those rooms that are occupied occasionally for short periods of time such as storage rooms, equipment rooms other than refrigeration machinery rooms, or a room which is capable of being entered with a door that is capable of being closed after entry.

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 its listing and 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 its listing and the manufacturer’s installation instructions.

3. Institutional occupancies where in accordance with Section 1105.6. [ASHRAE 15:7.2]

4. Where the airflow to an enclosed space served by a portion of an air-duct system cannot be shut off or reduced below one-quarter of its maximum, the cubical contents of the entire space served by that portion of the air-duct system shall be used to determine the permissible quantity of refrigerant in the system.

5. Refrigerated process or storage areas that comply with the requirements of Section 1105.3.

1105.2.1 Volume Calculations. The volume used to convert from refrigerant concentration limits to refrigerating system quantity limits for refrigerants in Section 1105.2 shall be based on the volume of space to which refrigerant disperses in the event of a refrigerant leak. [ASHRAE 15:7.3]

1105.2.2 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] Where the airflow to an enclosed space served by a portion of an air-duct system is not capable of being shut off or reduced below one-quarter of its maximum, the cubical contents of the entire space served by that portion of the air-duct system shall be used to determine the permissible quantity of refrigerant in the system.

1105.2.3 Plenums. Where the space above a suspended ceiling is not part of the air supply or return system, it shall not be included in calculating the refrigerant quantity limit of the system. [ASHRAE 15:7.3.2.2]

1105.6 Institutional Occupancies. The amount of refrigerant shown in Table 1102.2 shall be reduced by 50 percent for areas of institutional occupancies. The amount of Group A2, B2, A3, and B3 refrigerants shall not exceed 550 pounds (249.5 kg) in occupied areas and machinery rooms of institutional occupancies. [ASHRAE 15:7.2.1]

| TABLE 1105.1 |
| PERMISSIBLE REFRIGERATION SYSTEMS |

(portions of table not shown remain unchanged)
Notes:
1 See Section 1105.0.
2 A refrigerant shall be permitted to be used within a high-probability system where the room or space is in accordance with Section 1105.3.
3 The allowable quantities shown in Table 1102.2 shall be reduced by 50 percent for institutional occupancies except kitchens, laboratories, and mortuaries.
4 Occupancy classifications are defined in the building code.

SUBSTANTIATION:
1. Section 1105.2 is being revised to correlate the UMC with ASHRAE 15-2010 in regards to the refrigerant concentration limit for various spaces.
2. Section 1105.2.1 through Section 1105.2.3 are being added since currently the code is not clear on providing the minimum requirements on how to properly size a space in which a refrigerant will be present. To apply the refrigerant-per-volume requirements of Table 1102.2, the method of determining occupied spaces must be known. All occupied space requirements will correlate with ASHRAE 15-2010. Former Exception 1 in Section 1105.2 is being relocated to Section 1105.2.2 since it is where enclosed spaces are addressed. This is being done for ease of use of the code.
3. Section 1105.6 is being added since reference to institutional occupancies is being referenced in Exception 3 in Section 1105.2 per ASHRAE 15-2010. Institutional occupancies may consist of occupants who are incapable of readily leaving the facility without the assistance of others. Therefore, the amount of refrigerant should be reduced by 50 percent and the amount of A2, B2, A3, and B3 refrigerants be limited due to their high hazardous classifications. Furthermore, in Table 1105.1 note 3 is being deleted to avoid using redundant language that is already addressed in Section 1105.6.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed text was disapproved based on the concern that the language does not correlate with ASHRAE 15.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

1105.2 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 1102.2, except as provided in Section 1105.3 and Section 1105.6. The volume of the occupied space shall be determined in accordance with Section 1105.2.1 through Section 1105.2.3.

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]
(3) Institutional occupancies where in accordance with Section 1105.6. [ASHRAE 15:7.2]
(4) Industrial occupancies and refrigerated rooms where in accordance with Section 1105.3.

1105.2.1 Volume Calculations. The volume used to convert from refrigerant concentration limits to refrigerating system quantity limits for refrigerants in Section 1105.2 shall be based on the volume of space to which refrigerant disperses in the event of a refrigerant leak. [ASHRAE 15:7.3]
1105.2.2 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] Where the airflow to an enclosed space served by a portion of an air duct system is not capable of being shut off or reduced below one-quarter of its maximum, the cubical contents of the entire space served by that portion of the air duct system shall be used to determine the permissible quantity of refrigerant in the system.

1105.2.3 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 of the smallest volume in which the leaked refrigerant disperses shall be used to determine the refrigerant quantity limit, subject to the criteria in accordance with Section 1105.2.3.1 through Section 1105.2.3.3. [ASHRAE 15:7.3.2]

1105.2.3.1 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]

1105.2.3.2 Plenums. Where the space above a suspended ceiling is not part of the air supply or return system, it shall not be included in calculating the refrigerant quantity limit of the system unless such space is part of the air supply or return system. [ASHRAE 15:7.3.2.2]

1105.2.3.3 Supply and Return Ducts. The volume of the supply and return ducts and plenums shall be included where calculating the refrigerant quantity limit in the system. [ASHRAE 15:7.3.2.3]

1105.6 Institutional Occupancies. The amounts of refrigerant shown in Table 1102.2 shall be reduced by 50 percent for the areas of institutional occupancies. The total amount 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. [ASHRAE 15:7.2.1]

SUBSTANTIATION:
The Committee's reason for rejecting the proposal was that it did not correlate with ASHRAE 15. Therefore, the proposal has been revised to correlate completely with ASHRAE 15-2013 (latest version) in accordance with IAPMO's Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
1105.3 Refrigerated Process and Storage Areas Industrial Occupancies and Refrigerated Rooms. Refrigerant quantities in evaporators and piping within rooms or spaces used exclusively for processing or storage of materials under refrigerated conditions in industrial occupancies and refrigerated rooms shall not be limited, provided that egress is provided where in accordance with the building code and in accordance with Section 1105.3.1 through Section 1105.3.3 following:

1. **1105.3.2 Sealed.** The refrigerated room or space is sealed from other portions of the building by vapor-tight construction and tight-fitting, gasketed doors. The space containing the machinery is separated from other occupancies or spaces by tight construction with tight-fitting doors.

   **Exception:** Adjoining refrigerated rooms.

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 floor area shall not apply where the space is provided with egress directly to the outdoors or into approved building exits.

4. **1105.3.1 Refrigerant Room.** The refrigerated room or space is equipped with a refrigerant vapor detection and alarm system that is in accordance with Section 1121.0 Refrigerant detectors are installed with the sensing location and alarm level in accordance with Section 1107.4.

5. Open flames and surfaces exceeding 800°F (427°C) shall not be permitted where a Group A2, B2, A3, or B3 refrigerant, other than ammonia is used.

6. **1105.3.3 Lower Flammability Limit.** Where the quantity of a Group A2, B2, A3 or B3 refrigerant, other than ammonia, in an independent circuit will exceed 25 percent of the lower flammability limit where released to the surrounding room, the following shall be provided:

   **(1)** Electrical equipment shall comply with the requirements of the electrical code for Class I, Division 2.

   **(2)** The refrigerant vapor detection system required by Section 1105.3.1 shall automatically de-energize electrical power within the space at vapor concentrations at or above 25 percent of the lower flammability limit. Electrical equipment shall comply with Class I, Division 2 of NFPA 70 where the quantity of a Group A2, B2, A3, or B3 refrigerant, other than ammonia in an independent circuit, exceeds 25 percent of the lower flammability limit (LFL) upon release to the space based on the volume in accordance with Section 1105.2.

7. Refrigerant containing parts in systems exceeding 100 horsepower (74.6 kW) compressor drive power.

   **Exceptions:**

   (1) Evaporators used for refrigeration or dehumidification.

   (2) Condensers used for heating. [ASHRAE 15:7.2.2]

**SUBSTANTIATION:**

Section 1105.3 through Section 1105.3.3 are being revised to correlate with ASHRAE 15-2010. The proposed revision will provide requirements for industrial food processing plants, manufacturing plants, and refrigerator storage rooms. Items (1) through (7) provide the minimum requirements that occupancies and rooms shall comply with in order to be considered industrial occupancies or refrigerated rooms.

**COMMITTEE ACTION:** Reject

**COMMITTEE STATEMENT:**

The proposed text was disapproved based on the concern that the language does not correlate with ASHRAE 15.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

1105.3 Industrial Occupancies and Refrigerated Rooms. Refrigerant quantities within rooms or spaces used in industrial occupancies and refrigerated rooms shall not be limited where in accordance with following: Section 1105.2 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 or spaces 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 1107.4.

5. Open flames and surfaces exceeding 800°F (427°C) shall not be permitted where a Group A2, B2, A3, or B3 refrigerant, other than R-717 (ammonia), is used.

6. Electrical equipment shall comply that is in accordance with Class 1, Division 2, of NFPA 70 where the quantity of a Group A2, B2, A3, or B3 refrigerant, other than R-717 (ammonia) 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 1105.2.1.

7. Refrigerant containing parts in systems exceeding 100 horsepower (74.6 kW) compressor drive power. Exceptions: (1) except evaporators used for refrigeration or dehumidification, (2) Condensers used for heating, control and pressure-relief valves for either, and connecting piping, are located in a machinery room or outdoors.[ASHRAE 15:7.2.2]

SUBSTANTIATION:
The Committee’s reason for rejecting the proposal was that it did not correlate with ASHRAE 15. Therefore, the proposal has been revised to correlate completely with ASHRAE 15-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 145)

RECOMMENDATION:
Revise text as follows:

1107.6 Combustion Air and Return Air. No open flames that use combustion air or return air shall be taken from or through a refrigeration machinery room shall be installed where refrigerant is used. Combustion equipment shall not be installed in the same machinery room with refrigerant-containing equipment.

Exceptions:
(1) Refrigeration machinery rooms used exclusively for direct-fired absorption equipment Where carbon dioxide or water is the refrigerant.
(2) Direct-vented combustion equipment Combustion air is ducted from outside the machinery room and sealed to prevent refrigerant leakage from entering the combustion chamber.
(3) A refrigerant detector installed in accordance with Section 1107.4. The refrigerant detector shall automatically shut down the combustion process in the event of refrigerant leakage.
(4) Where ammonia is the refrigerant and internal combustion engines are used as the prime mover for the compressors. [ASHRAE 15:8.11.6]

1107.7 Special Requirements. Open flames or There shall be no flame-producing devices having an exposed or continuously operating hot surfaces exceeding over 800°F (427°C) permanently installed are prohibited in the refrigeration machinery rooms. [ASHRAE 15:8.12(a)]

Exceptions: (1) Momentary temperature excursions such as electrical contacts in A1 and B1 systems.
(2) Refrigeration machinery rooms used exclusively for direct-fired absorption equipment.

205.0
Combustion Chamber. The portion of an appliance within which combustion occurs. [NFPA 54:3.3.21]

SUBSTANTIATION:
1. In Section 1107.6 (Exception 1) the use of a direct-fired absorption system is being replaced with “where carbon dioxide or water as the refrigerant” to correlate with ASHRAE 15-2010. An absorption system uses water as one of the absorbent pair. An absorption cycle uses different refrigerants that have no associated environment hazard, ozone depletion, or global warming potential (for example a lithium bromide absorption system use distilled water as the refrigerant). Therefore, by indicating water as a refrigerant it would include absorption systems as well. Furthermore, carbon dioxide is permitted since carbon dioxide is nonflammable and nontoxic in contrast to other natural refrigerants.

2. In Section 1107.6 (Exception 2), the intent of the section is not being changed only the language used is being revised to correlate with ASHRAE 15-2010.

3. Section 1107.7 is being revised to correlate with ASHRAE 15-2010.

4. Section 1107.7 (Exception 2) is being removed since the provision is already addressed in Section 1107.6 (Exception 1), and therefore redundant.

5. The term “combustion chamber” is referenced in Section 1107.6(2) without being defined. Furthermore, the term is referenced in Sections 704.1, 924.3, 1310.1, and 1316.12.2.1 without being defined. The proposed definition assists the end user in applying and enforcing this term and will correlate with the definition used in NFPA 54-2012.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The proposed text was disapproved based on the concern that the language does not correlate with ASHRAE 15.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:

SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

RECOMMENDATION:

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

1107.6 Combustion Air and Return Air. No open flames that use combustion air or return air shall not be taken from or through a refrigeration 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 1106.4, shall be installed to automatically shut down the combustion process in the event of refrigerant leakage.

Exceptions:

1. Refrigeration machinery rooms used exclusively for direct-fired absorption equipment. Machinery rooms where carbon dioxide (R-744) or water (R-718) is the refrigerant.

2. Direct-vented combustion equipment. Machinery rooms where ammonia (R-717) is the refrigerant and internal combustion engines are used as the prime mover for the compressors. [ASHRAE 15:8.11.6]

1107.7 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 a 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]

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
1108.2 Refrigeration Machinery Rooms. Refrigeration machinery rooms shall be provided with dedicated mechanical exhaust systems. The exhaust systems shall have the capacity to achieve each of the following:

1. Limit the temperature rise within the refrigeration machinery room to a maximum of 104°F (40°C) as calculated by:

\[ Q = \frac{\sum q}{1.08 \Delta T} \]  

[Equation 1108.2(1)]

2. Provide emergency purge of escaping refrigerant at a rate of 30 air changes per hour (ACH) for ammonia, or for other refrigerants as calculated by:

\[ Q = 100 \sqrt{G} \]  

[Equation 1108.2(2)]

Where:
- \( q \) = British thermal unit per hour of heat-producing equipment.
- \( Q \) = Air-flow rate, cubic feet per minute.
- \( \Delta T \) = Temperature difference between machinery room and supply air, °F.
- \( G \) = Refrigerant mass in largest system, pounds.

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 cubic foot per minute = 0.00047 m³/s, °C = (°F - 32)/1.8, 1 pound = 0.453 kg

1108.4 Intermittent Control Use of the Ventilation Systems for Other Purposes. Fans providing refrigeration machinery room temperature control or automatic response to refrigerant gas in order to maintain concentrations below the PEL exhaust in accordance with Section 1108.2 shall be permitted to be automatically or manually controlled to provide intermittent ventilation as conditions require where the machinery room is occupied or in accordance with Section 1108.10.

1108.10 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.

SUBSTANTIATION:
Exhaust ventilation is not the only means for keeping a mechanical room below 104°F. In fact in a hot climate where the outdoor air temperature can be above 104°F, it is impossible to cool the room with exhaust and outdoor air makeup. In these rooms, mechanical cooling must be provided. So the requirement to meet the 104°F limit with the exhaust fan is eliminated and this requirement is moved to an added subsection that allows either mechanical cooling or ventilation. Also, noted are that the 104°F maximum must be met at design load and weather conditions, not mentioned in the previous wording but necessary. Section 1108.4 is revised to allow the refrigerant exhaust fan to be used for general ventilation purposes when the space is occupied and to meet the 104°F limit if applicable.

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

1107.11 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]

SUBSTANTIATION:
Section 1107.11 is being added as it is necessary for the temperature of ducts used in a mechanical ventilation system to not exceed 700°F. Section 1108.10 addresses ventilation system requirements but failed to mention the maximum temperature permitted in refrigerant parts in air ducts. Furthermore, Section 1107.11 will correlate with ASHRAE 15-2013.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (new Section 1107.11 on maximum duct temperature) not published in the ROP as part of the proposal being commented on. The committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”
**SUBMITTER:** Steve Ferguson  
The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

**RECOMMENDATION:**  
Revise text as follows:

### TABLE 1102.2

**REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES**

[ASHRAE 34: TABLE 1, TABLE 2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP</th>
<th>OEL (PPM)</th>
<th>IDLH (PPM)</th>
<th>POUNDS PER 1000 CF OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-30</td>
<td>CH₂Cl₂</td>
<td>Dichloromethane (methylene chloride)</td>
<td>B₂B₁</td>
<td>C₁₀₀₀</td>
<td>2300</td>
<td>–</td>
</tr>
<tr>
<td>R-32</td>
<td>CH₂F₂</td>
<td>Difluoromethane (methylene fluoride)</td>
<td>A₂</td>
<td>10₀₀</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>R-143a</td>
<td>CH₃CF₃</td>
<td>1,1,1-trifluoroethane</td>
<td>A₂</td>
<td>10₀₀</td>
<td>–</td>
<td>4.5</td>
</tr>
<tr>
<td>R-400</td>
<td>zebrope</td>
<td>R-12/114 (50.0/50.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>R-400</td>
<td>zebrope</td>
<td>R-12/114 (60/40)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>R-402A</td>
<td>zebrope</td>
<td>R-125/290/22 (60/2.0/38.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>8.5 17</td>
<td></td>
</tr>
<tr>
<td>R-407A</td>
<td>zebrope</td>
<td>R-32/125/134a (20.0/40.0/40.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>48 19</td>
<td></td>
</tr>
<tr>
<td>R-407B</td>
<td>zebrope</td>
<td>R-32/125/134a (10.0/70.0/20.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>20 21</td>
<td></td>
</tr>
<tr>
<td>R-407C</td>
<td>zebrope</td>
<td>R-32/125/134a (23.0/25.0/52.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>47 18</td>
<td></td>
</tr>
<tr>
<td>R-407D</td>
<td>zebrope</td>
<td>R-32/125/134a (15.0/15.0/70.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>44 16</td>
<td></td>
</tr>
<tr>
<td>R-407E</td>
<td>zebrope</td>
<td>R-32/125/134a (25.0/15.0/60.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>46 17</td>
<td></td>
</tr>
<tr>
<td>R-407F</td>
<td>zebrope</td>
<td>R-32/125/134a (30.0/30.0/40.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>44 20</td>
<td></td>
</tr>
<tr>
<td>R-410A</td>
<td>zebrope</td>
<td>R-32/125 (50.0/50.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>25 26</td>
<td></td>
</tr>
<tr>
<td>R-410B</td>
<td>zebrope</td>
<td>R-32/125 (45.0/55.0)</td>
<td>A₁</td>
<td>10₀₀</td>
<td>24 27</td>
<td></td>
</tr>
<tr>
<td>R-415A</td>
<td>zebrope</td>
<td>R-22/152a (82.0/18.0)</td>
<td>A₂</td>
<td>10₀₀</td>
<td>42 29</td>
<td></td>
</tr>
<tr>
<td>R-415B</td>
<td>zebrope</td>
<td>R-22/152a (25.0/75.0)</td>
<td>A₂</td>
<td>10₀₀</td>
<td>93 21</td>
<td></td>
</tr>
<tr>
<td>R-418A</td>
<td>zebrope</td>
<td>R-290/22/152a (1.5/96.0/2.5)</td>
<td>A₂</td>
<td>10₀₀</td>
<td>43 4.8</td>
<td></td>
</tr>
<tr>
<td>R-419A</td>
<td>zebrope</td>
<td>R-125/134a/E170 (77.0/19.0/4.0)</td>
<td>A₂</td>
<td>10₀₀</td>
<td>44 4.2</td>
<td></td>
</tr>
<tr>
<td>R-432A</td>
<td>zebrope</td>
<td>R-1270/E170 (80.0/20.0)</td>
<td>A₃</td>
<td>7₀₀</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>R-436A</td>
<td>zebrope</td>
<td>R-290/600a (56.0/44.0)</td>
<td>A₃</td>
<td>10₀₀</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>R-436B</td>
<td>zebrope</td>
<td>R-290/600a (52.0/48.0)</td>
<td>A₃</td>
<td>10₀₀</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>R-437A</td>
<td>zebrope</td>
<td>R-125/134a/600/601 (19.5/78.5/1.4/0.6)</td>
<td>A₁</td>
<td>9₉₀</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>R-439A</td>
<td>zebrope</td>
<td>R-32/125/600a (50.0/47.0/3.0)</td>
<td>A₂</td>
<td>9₉₀</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>R-440A</td>
<td>zebrope</td>
<td>R-290/134a/152a (0.6/1.6/97.8)</td>
<td>A₂</td>
<td>10₀₀</td>
<td>1.9</td>
<td></td>
</tr>
</tbody>
</table>
1 – 15 (remaining text unchanged)

**203.0**

**Azeotrope.** A refrigerant blend comprising multiple components of different volatiles that, when used in refrigeration cycles, do not change volumetric composition or saturation temperature as they evaporate or condense at constant pressure. 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 \( \frac{dt}{dx}p = 0 \), 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]

**208.0**

**Flammable Vapor or Fumes.** The refrigerant flammable concentration limit in air and intended to reduce the risk of fire or explosion in normally occupied, enclosed spaces. The limit occurs where the concentration of flammable constituents in air exceeds 25 percent of its Lower Flammability Limit (LFL).
214.0

LFL (Lower Flammable Limit or Lower Limit of Flammability). The minimum concentration of a combustible substance that propagates a flame through a homogeneous mixture of the substance and air that is capable of propagating a flame through a homogeneous mixture of the combustible and a gaseous oxidizer under the specified test conditions of test. The LFL is sometimes referred to as LEL (Lower Explosive Limit). For the purposes of this definition, LFL and LEL are identical.

217.0

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, AIHA WEEL, or consistent value. [ASHRAE 34:3]

218.0

PEL (Permissible Exposure Limit). The maximum permitted eight-hour time-weighted average concentration of an airborne contaminant. 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.

220.0

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 indicates refrigerants that do not show flame propagation in air where tested by prescribed methods at specified conditions. Classes 2 and 3 signify refrigerants with “lower flammability” and “higher flammability,” respectively. The distinction depends on both the Lower Flammability Limit (LFL) and heat of combustion.

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) \((0.10012 \text{ kg/m}^3)\) at 140°F (60°C), 14.7 psia (101 kPa), and a heat of combustion of less than 8169 British thermal unit per pound (Btu/lb) \((1.8988 \text{ E+07 J/kg})\).

Class 3. Refrigerants that are highly flammable, having a LFL of less than or equal to 0.00625 \((0.10012 \text{ kg/m}^3)\) at 140°F (60°C) and 14.7 psia (101 kPa) or a heat of combustion not less than 8169 Btu/lb \((1.8988 \text{ E+07 J/kg})\).

Toxicity Classification. Classes A and B signify refrigerants with “lower toxicity” and “higher toxicity,” respectively, based on prescribed measures of chronic (long-term, repeated exposures) toxicity. 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.

SUBSTANTIATION:
The following definitions are being modified or added to be consistent with the current content of ANSI/ASHRAE Standard 34-2010 and its published Addenda:

1. The definition of AZEOTROPIC is being modified to make it more technically precise and easier to understand. This is an editorial change.

2. The definition of FLAMMABLE VAPOR OR FUMES is being modified to make it easier to understand as it is applied. This is an editorial change.

3. The definition of LFL (LOWER FLAMMABLE LIMIT OR LOWER LIMIT OF FLAMMABILITY) is being modified to be more technically correct and clear. This is an editorial change and does not result in a change to the flammability classification of any refrigerants in Table 1102.2.

4. A definition of OCCUPATIONAL EXPOSURE LIMIT (OEL) is being added because it is used and footnoted in a reference in Table 1102.2, but not adequately described as used to determine the toxicity classification of a
refrigerant. This definition does not result in a change to the toxicity classification or the OEL (ppm) values in Table 1102.2. This definition is a generic term, and allows the use of OELs from various organizations that evaluate the toxicity of refrigerants and publish exposure limits, e.g. Workplace Environmental Exposure Limit (WEEL) from the American Industrial Hygiene Association (AIHA), Threshold Limit Values – Time Weighted Average (TLV-TWA) from the American Conference of Governmental Industrial Hygienists (ACGIH), Permissible Exposure Limits (PEL) from the National Institute for Occupational Safety and Health (NIOSH).

5. The definition of PEL (PERMISSIBLE EXPOSURE LIMIT) is being modified to be more technically correct and explanatory. It does not result in a change to the toxicity classification of any refrigerants in Table 1102.2.

6. The definition of TOXICITY is being modified to make it easier to understand, and to add Toxicity Classification definitions for Class A and Class B consistent with ASHRAE Standard 34. This is an editorial change and does not result in a change to the toxicity classification of any refrigerants in Table 1102.2.

7. The definition of FLAMMABILITY is being modified to make it easier to understand, and to add Flammability Classification definitions for Class 1, Class 2, and Class 3 consistent with ASHRAE Standard 34. This is an editorial change and does not result in a change to the flammability classification of any refrigerants in Table 1102.2.

8. The test temperature for determining flame propagation and for measuring the LFL of a refrigerant has been modified to be consistent with common practice today and with the requirements of ANSI/ASHRAE Standard 34. The higher test temperature is a more conservative measure of the LFL.

**TABLE 1102.2: REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES**

Several new refrigerants have been developed to replace ozone depleting substances and/or to replace refrigerants with a high global warming potential. Eleven refrigerants have been added to ANSI/ASHRAE Standard 34 since publication of the 2012 UMC. These refrigerants are: R-439A, R-440A, R-441A, R-442A, R-443A, R-444A, R-511A, R-512A, and R-1234ze(E).

Corrections were made to the amount of refrigerant per occupied space for R-402A, R-415A, R-418A, R-419A, R-436A, R-436B, R-437A, R-511A, R-512A, R-600, R-600a, R-601, R-601a, and R-1270. These changes are being made to correct errors in the 2012 UMC.

Corrections were made to the OEL limits for R-432A, R-717, and R-1234yf. These changes are being made to correct errors in the 2012 UMC.

The cardiac sensitization NOEL for R-32 has been changed in Standard 34 from 200,000 ppm to 350,000 ppm based on more recent studies using acceptable GLP methodology. This had no effect on the amount of refrigerant per occupied space for R-32 but did result in changes to the amount of refrigerant per occupied space for refrigerant blends containing R-32 and these have been changed accordingly (i.e. R-407A, R-407B, R-407C, R-407D, R-407E, R-410A, R-410B, and R-504).

Corrections were made to the Safety Group Classifications for R-30. These changes are being made to correct errors in the 2012 UMC.

ASHRAE recently added a new flammability classification, “2L” to ASHRAE Standard 34, Designation and Safety Classification of Refrigerants. However, application instructions for 2L refrigerants are still under development so the new flammability classification is not being introduced into the codes at this time. As a result we are adding a footnote to Table 11-1 indicating that the ASHRAE Standard 34 flammability classification for refrigerants R-32, R-143a, R-717, R-1234yf, R-444A and R-1234ze(E) is Class 2L, which is a subclass of Class 2.

**COMMITTEE ACTION:** Accept as Amended by the TC

Amend proposal as follows:

208.0

**flammable vapor or fumes.** The refrigerant flammable concentration limit in air and intended to reduce the risk of fire or explosion in normally occupied, enclosed spaces. The This limit occurs where the concentration of flammable constituents in air exceeds 25 percent of its Lower Flammability Limit (LFL).

**COMMITTEE STATEMENT:**

The definition for “flammable vapor or fumes” was modified since it does not apply to only refrigerants. Flammable vapors are addressed in Chapter 5 for product conveying ducts as well.
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Tim Ross, Ross Distributing, Inc.

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

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA</th>
<th>CHEMICAL NAME (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP</th>
<th>OEL (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 networks¹</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-13</td>
<td>CClF3</td>
<td>Chlorotrifluoroethane</td>
<td>A1</td>
<td>1000 networks³</td>
<td>—</td>
</tr>
<tr>
<td>R-13B1</td>
<td>CBrF3</td>
<td>Bromotrifluoroethane</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 networks³</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>CHCIF2</td>
<td>Chlorodifluoroethane</td>
<td>A1</td>
<td>1000 networks³</td>
<td>13</td>
</tr>
<tr>
<td>R-23</td>
<td>CHF3</td>
<td>Trifluoroethane</td>
<td>A1</td>
<td>1000 networks³</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-32</td>
<td>CH2F2</td>
<td>Difluoroethane (methylene fluoride)</td>
<td>A2L networks⁴</td>
<td>1000 networks³</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>
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<tr>
<td>R-50</td>
<td>CH4</td>
<td>Methane</td>
<td>A3</td>
<td>1000 networks³</td>
<td>—</td>
</tr>
<tr>
<td>R-113</td>
<td>CCl2FCClF</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>CClF2CClF</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>CClF2CF3</td>
<td>Chloropentafluoroethane</td>
<td>A1</td>
<td>1000 networks³</td>
<td>47</td>
</tr>
<tr>
<td>R-116</td>
<td>CF3CF3</td>
<td>Hexafluoroethane</td>
<td>A1</td>
<td>1000 networks³</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 networks⁵</td>
<td>3.5</td>
</tr>
<tr>
<td>R-124</td>
<td>CHCIFCF3</td>
<td>2-chloro-1, 1, 1, 2 - tetrafluoroethane</td>
<td>A1</td>
<td>1000 networks³</td>
<td>3.5</td>
</tr>
<tr>
<td>R-125</td>
<td>CHF2CF3</td>
<td>Pentfluoroethane</td>
<td>A1</td>
<td>1000 networks³</td>
<td>23</td>
</tr>
<tr>
<td>R-134a</td>
<td>CH2CF3</td>
<td>1, 1, 1, 2-tetrafluoroethane</td>
<td>A1</td>
<td>1000 networks³</td>
<td>13</td>
</tr>
<tr>
<td>R-141b</td>
<td>CH3CCl2F</td>
<td>1, 1-dichloro-1-fluoroethane</td>
<td>—</td>
<td>500 networks⁵</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 networks³</td>
<td>5.1</td>
</tr>
<tr>
<td>R-143a</td>
<td>CH3CF3</td>
<td>1, 1, 1-trifluoroethane</td>
<td>A2L networks⁴</td>
<td>1000 networks³</td>
<td>4.5</td>
</tr>
<tr>
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| REFRIGERANT | CHEMICAL FORMULA | CHEMICAL NAME
(Composition for Blends) | SAFETY GROUP | OEL (ppm) | POUNDS PER 1000 CUBIC FEET OF SPACE |
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**TABLE 1102.2 (continued)**

**REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES**

**[ASHRAE 34: TABLE 4-1, TABLE 4-2]**

For SI units: 1 pound = 0.453 kg, 1 cubic foot = 0.0283 m³

Notes:
1. Refrigerant safety group designation is in accordance with Section 1103.0.
2. Refrigerant properties are those needed for this chapter.
3. Allowable quantities are for high-probability systems under Section 1103.2.
4. Chemical name shown is the preferred name followed by the popular name in parenthesis.
5. The OEL are 8-hour TWA; a C designation denotes a ceiling unit limit.
6. Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated.
7. The extent of segregation depends on the particular azeotrope and hardware system configuration.
8. The exact composition of this azeotrope is in question, and additional experimental studies are needed.

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<th>REFRIGERANT</th>
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<th>SAFETY GROUP</th>
<th>OEL (ppm)</th>
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<td>R-600</td>
<td>CH₃CH₂CH₃</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>CH₃CH₂CH₂CH₂CH₂C</td>
<td>Pentane</td>
<td>A3</td>
<td>600</td>
<td>0.18</td>
</tr>
<tr>
<td>R-601a</td>
<td>(CH₃)₂CHCH₂CH₂CH₃</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>HCOOHCH₃</td>
<td>Methyl formate</td>
<td>B2</td>
<td>100</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>B2L²</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>See footnote 11</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-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>4.5</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-1150</td>
<td>CH₂=CH₂</td>
<td>Ethene (ethylene)</td>
<td>A3</td>
<td>200</td>
<td>—</td>
</tr>
<tr>
<td>R-1234yf</td>
<td>CF₃CF=CH₂</td>
<td>2, 3, 3, 3-tetrafluoro-1-propene</td>
<td>A2L²</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>A2L²</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>
</tbody>
</table>

For SI units: 1 pound = 0.453 kg, 1 cubic foot = 0.0283 m³
R-507, R-508, and R-509 shall be permitted 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.

The amount of refrigerant per occupied space 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.

Pounds (kg) of refrigerant in a high-probability system per 1000 cubic feet (28.32 m³) of occupied space. See Section 1103.2. This column does not apply to refrigerant machinery rooms or areas covered by Section 1106.0. Where no value is listed use zero unless data is capable of being provided to determine the value in accordance with ASHRAE 34.

The OEL value shown is the TLV-C recommended by ACGIH.

A OEL has not yet been established; the value given was determined in a consistent manner.

The OEL value shown is the WEEL recommended by AIHA.

The OEL value shown is the ACGIH TLV-TWA.

Quantity is unlimited where R-718 (water) is used as the refrigerant.

Flammability classification for the refrigerant is 2L, which is a subclass of class 2.

SUBSTANTIATION:
Table 1102.2 is being modified to correlate with ASHRAE 34-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

TABLE 1102.2
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(^2)</th>
<th>OEL(^2) (PPM)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-446A</td>
<td>zeotrope</td>
<td>R-32/1234ze(E)/600 (68.0/29.0/3.0)</td>
<td>A2L</td>
<td>960</td>
<td>2.5</td>
</tr>
<tr>
<td>R-447A</td>
<td>zeotrope</td>
<td>R-32/125/1234ze(E) (68.0/3.5/28.5)</td>
<td>A2L</td>
<td>900</td>
<td>2.6</td>
</tr>
<tr>
<td>R-1233zd(E)</td>
<td>CF₂CH=CHCl</td>
<td>Trans-1-chloro-3,3,3-trifluoro-1-propene</td>
<td>A1</td>
<td>800</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Notes:
(1) - (6) (remain unchanged)

Refrigerant flammability classification of Class 2L shall comply with the requirements for flammability classification of Class 2.

(portions of table not shown remain unchanged)

COMMITTEE STATEMENT:
The proposed modification will correlate with the latest addenda “addenda a, b, and c” published by ASHRAE 34 to the ASHRAE 34-2013.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
1114.2 Positive-Displacement Compressor. A positive-displacement compressor shall be equipped by the manufacturer with a stop valve in the discharge connection shall be equipped with a pressure-relief device of approved size and pressure setting to prevent rupture of the compressor or other component located between the compressor and the stop valve on the discharge side 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 1117.5, whichever is larger. The pressure-relief device shall discharge into the low-pressure side of the system or in accordance with Section 1117.8.

Exception: Hermetic refrigerant motor-compressors that are listed and have a displacement not more than 50 cubic feet per minute (1.42 m$^3$/min) [ASHRAE 15:9.8]

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 1114.2(1), Section 1114.2(2), and Section 1114.2(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.

Exception: Hermetic refrigerant motor-compressors that are listed and have a displacement not more than 50 cubic feet per minute (1.42 m³/min). [ASHRAE 15:9.8]

SUBSTANTIATION:
Section 1114.2 is being modified to correlate with ASHRAE 15-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). The modification will add discharge requirements for relief devices that are based on the compressor flow, which currently is not addressed in the original proposal.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

1114.2 Positive-Displacement Compressor. Except for hermetic refrigerant motor-compressors that are listed and have a displacement not more than 50 cubic feet per minute (1.42 m³/min). 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 1117.5, whichever is larger. The pressure-relief device shall discharge into the low-pressure side of the system or in accordance with Section 1117.8.

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 1114.2(1), Section 1114.2(2), and Section 1114.2(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]

COMMITTEE STATEMENT:
Section 1114.2 is being modified to further clarify the intent of the section in regards to positive-displacement compressors.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 168)

RECOMMENDATION:
Revise text as follows:

1117.6 1114.10 Rating of Pressure-Relief Valves Device. Pressure relief valves shall be of approved types and capacities. The rated discharge capacity of a pressure-relief valve device shall be 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]

1117.7 1114.11 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 by in accordance with the following formulas:

(remaining text unchanged)

SUBSTANTIATION:
Section 1117.6 and Section 1117.7 are being relocated to Section 1114.10 and Section 1114.11 where all provisions for pressure-relief valves are addressed. Furthermore, Section 1117.6 is being revised to correlate with ASHRAE 15-2010 in regards to the rating of pressure relief devices. All other revisions are being done to comply with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

1112.8 Pressure-Relief Device Settings. Pressure-relief valves shall actuate 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 Pressure Vessels. The application of pressure-relief valves that discharge from a higher-pressure vessel into a lower-pressure vessel of 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 exceeding the maximum allowable working pressure of the higher-pressure vessel accounting for the change in mass flow capacity due to the elevated back pressure.

(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 15:9.7.8.1]
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 m$^3$) or more internal gross volume except under the conditions permitted in Section 1112.10.1. [ASHRAE 15:9.7.3]

(renumber remaining sections)

SUBSTANTIATION:
An exception is necessary to Section 1112.8 as the setting pressure for pressure relief valves that discharge from a higher-pressure vessel into a lower-pressure vessels, which is commonly used in a refrigeration system, is not taken into consideration. Therefore, Section 1112.10.1 and Section 1113.3 are necessary to address such scenario and it will correlate with ASHRAE 15-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

Section 1112.10.1 is necessary as Section 1001.1(6) refers the end user to Chapter 11 for pressure vessel requirements used in refrigeration systems. For information purposes only, Section 1001.1(6) is shown as follows: Pressure vessels used in refrigeration systems shall comply with Chapter 11. As of now, there are no pressure vessel requirements in Chapter 11. Therefore, Section 1112.10 should be modified and Sections 1112.10.1 and 1113.3 should be added to make the statement in Section 1001.1(6) true.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected in favor of Public Comment 2 as it correlates with “addenda a” of ASHRAE 15-2013.

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

1112.8 Pressure-Relief Device Settings. Pressure-relief valves shall actuate 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 Discharge Location. Pressure-relief devices and fusible plugs shall discharge to the outdoors at a location not less than 15 feet (4572 mm) above the adjoining ground level and not less than 20 feet (6096 mm) from a ventilation opening or an opening into a building for the following systems:
1. Systems containing a Group A3 or B3 refrigerant.
2. Systems containing more than 6.6 pounds (2.99 kg) of a Group A2, B1, or B2 refrigerant.
3. Systems containing more than 110 pounds (49.9 kg) of a Group A1 refrigerant.
4. Systems where a machinery room is required.

The discharge shall be terminated to prevent both the discharged refrigerant from being sprayed directly on personnel in the vicinity and foreign material or debris from entering the discharge piping. Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging the pipe where the fusible plug or rupture member functions. Systems using water as the refrigerant are permitted to discharge to a floor drain where in accordance with the following:

(Fill in the remaining sections as necessary)
The pressure relief device set pressure does not exceed 15 psig (103 kPa).

The floor drain is sized to handle not less than the flow rate from a single broken tube in a refrigerant-containing heat exchanger.

The additives used in the refrigeration system shall be approved by the Authority Having Jurisdiction or a catch tank shall be installed, sized to handle the expected discharge, and shall be equipped with a normally closed drain valve and an overflow line to the drain. [ASHRAE 15:9.7.8]

1112.10 Discharge from Pressure-Relief Devices. Pressure-relief systems designed for vapor shall comply with Section 1112.10.1 through Section 1112.10.4.1.

1112.10.1 Discharging Location Interior to Building. Pressure-relief devices, including fusible plugs, serving refrigeration systems shall be permitted to discharge to the interior of a building where in accordance with the following:

(1) The system contains less than 110 pounds (49.9 kg) of a Group A1 refrigerant.
(2) The system contains less than 6.6 pounds (2.99 kg) of a Group A2, B1 or B2 refrigerant.
(3) The system does not contain any quantity of a Group A3 or B3 refrigerant.
(4) The system is not required to be installed in a machinery room in accordance with Section 1106.0.
(5) The refrigerant concentration limits in Section 1104.0 are not exceeded. Refrigeration systems that do not comply with the above requirements shall comply with the requirements of Section 1112.10.2 through Section 1112.10.4. [ASHRAE 15:9.7.8.1]

1112.10.2 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 might be 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 minimum of 24 inches (610 mm) in length 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]

1112.10.3 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 exceeding 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 at least 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]

1112.10.4 Discharge Location, Special Requirements. Additional requirements for relief device discharge location and allowances shall apply for specific refrigerants in accordance with Section 1112.10.4.1. [ASHRAE 15:9.7.8.4]

1112.10.4.1 Water (R-718). Where water is the refrigerant, discharge to a floor drain shall be permitted where the following conditions are met:
The pressure-relief device set pressure shall not exceed 15 psig (103 kPa).

The floor drain shall be sized to handle the flow rate from a single broken tube in a refrigerant-containing heat exchanger.

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]

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 m$^3$) or more internal gross volume except under the conditions permitted in Section 1112.10.1. [ASHRAE 15:9.7.3]

SUBSTANTIATION:

An exception is necessary to Section 1112.8 as the setting pressure for pressure relief valves that discharge from a higher-pressure vessel into a lower-pressure vessels, which is commonly used in a refrigeration system, is not taken into consideration. Therefore, Section 1112.10.1 through Section 1112.10.4.2, and Section 1113.3 are necessary to address such scenario so that it correlates will correlate with ASHRAE 15-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines) and “addenda a” to ASHRAE 15-2013.

Section 1112.10.3 is necessary as Section 1001.1(6) refers the end user to Chapter 11 for pressure vessel requirements used in refrigeration systems. For information purposes only, Section 1001.1(6) is shown as follows: Pressure vessels used in refrigeration systems shall comply with Chapter 11. As of now, there are no pressure vessel requirements in Chapter 11. Therefore, Section 1112.10 should be modified and Sections 1112.10.1 and 1113.3 should be added to make the statement in Section 1001.1(6) true.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (revisions to Section 1112.8, deletion of Section 1112.10 and a new Section 1112.10) not published in the ROP as part of the proposal being Commented on. The committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:

“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 166)

RECOMMENDATION:
Revise text as follows:

1118.0 1114.9 Discharge Piping. 1118.1 General. The size of the discharge pipe from the pressure-relief device or fusible plug shall be not less than as large as the outlet area size of the pressure-relief device or fusible plug. Where outlets of a discharge pipe accepting discharge from two or more than one relief devices or fusible plugs shall be sized and have a maximum length of the common discharge not less than that required by the sum of the rated capacities of relief valves discharging into the header at the lowest pressure setting of the relief valve discharging into the header are connected to a common line or header, the effect of back pressure that will be developed where more than one relief device or fusible plug operates shall be considered. The sizing of the common discharge header downstream from the two or more relief devices or fusible plugs that operate simultaneously shall be based on the sum of their outlet areas and the pressure drops in downstream sections. [ASHRAE 15:9.7.8.4]

The maximum length of the discharge piping permitted to be installed on the outlet of a pressure-relief devices and fusible plugs discharging to the outdoors shall be determined by in accordance with Equation 1114.9(1) and Equation 1114.9(2):

\[ L = 9 P^2 \frac{d^5}{16C^2} \]  

Where:
\( C \) = Minimum required discharge capacity, pounds of air per minute.  
\( d \) = Internal diameter of pipe, inches.  
\( L \) = Length of discharge pipe, inches.

For relief valves and rupture disks:

\[ P = \text{(rated pressure in psig x 1.1) + 14.7} \]

For fusible plugs \( P = P_f \)

\( P_f \) = 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, psia.

For SI units: 1 pound per minute = 0.00756 kg/s, 1 inch = 25.4 mm, 1 pound-force per square inch = 6.8947 kPa

SUBSTANTIATION:
Section 1118.0 and Section 1118.1 are being relocated to Section 1114.9 where provisions for pressure-relief valves are addressed. Furthermore, Section 1118.1 is being revised to correlate the UMC with ASHRAE 15-2010 in regards to the discharge of pressure-relief valves. All other changes are being done to comply with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.

1112.7 Common Discharge Header. Where relief valves are connected to discharge to a common discharge header as in accordance with Section 1114.9, a full area stop valve shall be permitted to be installed in the discharge pipe between the relief valve and the common header. Where such a stop valve is installed, a locking device shall be installed to ensure that the stop valve is locked in the open position. This discharge stop valve shall not be shut unless one of the following conditions exists:
1. A parallel relief valve is installed that protects the system or vessels.
2. The system or vessels being protected have been depressurized and are vented to the atmosphere. [ASHRAE 15:9.4.7]

1114.9 Discharge Piping. The size of the discharge pipe from the pressure-relief device or fusible plug shall be not less than the outlet size of the pressure-relief device or fusible plug. Where outlets of two or more relief devices or fusible plugs are connected to a common line or header, the effect of back pressure that will be developed where more than one relief device or fusible plug operates shall be considered. The sizing of the common discharge header downstream from each of the two or more relief devices or fusible plugs that are expected to operate simultaneously shall be based on the sum of their outlet areas with due allowance for and the pressure drops in the downstream sections. [ASHRAE 15:9.7.8.4]

1114.9.1 Maximum Length. The maximum length of the discharge piping installed on the outlet of pressure-relief devices and fusible plugs discharging to the outdoors atmosphere shall be determined in accordance with Section 1114.9.1 through Section 1114.9.3, Equation 1114.9(1) and Equation 1114.9(2), for the flow capacity of various equivalent lengths of discharge piping for conventional relief valves. [ASHRAE 15:9.7.8.5]

1114.9.2 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 in accordance with Equation 1114.9.2(1).

\[
L = 9P^2d^4C^2
\]

\[
L = 0.2146d^2 \left( \frac{P_z^2 - P_0^2}{fC^2} \right) - \frac{d \ln \left( \frac{P_z}{P_0} \right)}{6f}
\]

[Equation 1114.9.2(1)]

Where:
- \(C\) = Minimum required discharge capacity, pounds of air per minute.
- \(L\) = Equivalent Length of discharge piping, inches feet
- \(Cr\) = Rated capacity as stamped on the relief device in pound per minute, or in SCFM multiplied by 0.0764, or as calculated in Section 1112.12 for a rupture member or fusible plug, or as adjusted for reduced capacity due to piping 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.
- \(d\) = Internal Inside diameter of pipe or tube, inches.
- \(ln\) = Natural logarithm
- \(P_z\) = Absolute pressure at outlet of discharge piping, psia
- \(P_0\) = Allowed back pressure (absolute) at the outlet of pressure relief device in accordance with Equation 1114.9.2(2) through Equation 1114.9.2(4), psia

For relief valves and rupture disks:

[Equation 1112.9(2)]

\(P = \) (rated pressure in psig x 1.1) + 14.7

For fusible plugs \(P = P_{I}\). \(P_{I}\) = 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, psia.

For allowable back pressure \(P_0\), use the percent of set pressure specified by the manufacturer, or, where the allowed back pressure is not specified, the following shall be permitted to be used, where \(P\) is the set pressure:
For conventional relief valves, 15 percent of set pressure:
\[ P_0 = (0.15 X P_a) + P_a \]  \[\text{Equation 1114.9.2(2)}\]

For balanced relief valves, 25 percent of set pressure:
\[ P_0 = (0.25 X P_a) + P_a \]  \[\text{Equation 1114.9.2(3)}\]

For rupture disks alone, fusible plugs, and pilot operated relief devices, 50 percent of set pressure:
\[ P_0 = (0.50 X P_a) + P_a \]  \[\text{Equation 1114.9.2(4)}\]

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, psi (kPa), and atmospheric pressure shall be at the elevation of the installation above sea level. A default value shall be the atmospheric pressure at sea level, 14.7 psia (101 kPa). [ASHRAE 15:Appendix D]

**SUBSTANTIATION:**
Section 1114.9 is being modified to correlate with ASHRAE 15-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). The original proposed language did not correlate with ASHRAE 15 to meet the IAPMO Manual of Style. However, the text that was left out was necessary as it changes the intent of the section. Furthermore, Section 1112.7 is being added as it is required for common discharge headers. Section 1114.9 addresses sizing of common discharge headers and Section 1112.7 addresses requirements for relief valves connected to a common discharge header, such as locking devices. Locking devices are extremely important where a common discharge header is used to ensure that the stop valve permitted between the header and the relief valve remains open at all times.

Furthermore, in 2000, ASHRAE updated the equation used to calculate the maximum allowable line length. The line length equation for pressure relief valves currently in the UMC is based on an old line length equation from ASHRAE 15-1994. The updated discharge pipe length equation allows designers to properly engineer relief systems, and to ensure their safe operation by limiting the backpressure on relief valves to a level where their performance will not be adversely affected. Furthermore, the current equation cannot be used to properly analyze or engineer manifolde d or headered relief systems. As such, the proposed changes are acute from a safety perspective. In addition, the proposed revisions would re-align the UMC with the current version of ASHRAE 15.

**COMMITTEE ACTION:** Reject the public comment

**COMMITTEE STATEMENT:**
The public comment is being rejected in favor of Public Comment 2 as it correlates with “addenda a” of ASHRAE 15-2013.

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:** 
**AFFIRMATIVE:** 21  
**NOT RETURNED:** 1 Garza

**PUBLIC COMMENT 2:**
**SUBMITTER:** Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

1114.9 Discharge Piping. The piping used for pressure-relief device discharge shall be in accordance with Section 1114.9.1 through Section 1114.9.5. [ASHRAE 15:9.7.9]

1114.9.1 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]
1114.9.2 Pipe Size. The size of the discharge pipe from the pressure-relief device or fusible plug shall be not less than the outlet size of the pressure-relief device or fusible plug. Where outlets of two or more relief devices or fusible plugs are connected to a common line or header, the effect of back pressure that will be developed where more than one relief device or fusible plug operates shall be considered. The sizing of the common discharge header downstream from the two or more relief devices or fusible plugs that operate simultaneously shall be based on the sum of their outlet areas and the pressure drops in downstream sections. [ASHRAE 15:9.7.8.4(9.7.9.2)]

1114.9.3 Maximum Length. The maximum length of the discharge piping installed on the outlet of pressure-relief devices and fusible plugs discharging to the outdoors atmosphere shall be determined in accordance with Section 1114.9.4 and Section 1114.9.5 (Equation 1114.9(1) and Equation 1114.9(2)). See Table 1114.9.3 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]

### Table 1114.9.3

<table>
<thead>
<tr>
<th>ELEVATION ABOVE SEA LEVEL, FEET</th>
<th>POUNDS PER SQUARE INCH, ABSOLUTE (P&lt;sub&gt;a&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.7</td>
</tr>
<tr>
<td>500</td>
<td>14.4</td>
</tr>
<tr>
<td>1000</td>
<td>14.2</td>
</tr>
<tr>
<td>1500</td>
<td>13.9</td>
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<tr>
<td>2000</td>
<td>13.7</td>
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<tr>
<td>2500</td>
<td>13.4</td>
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<tr>
<td>8000</td>
<td>10.9</td>
</tr>
<tr>
<td>9000</td>
<td>10.5</td>
</tr>
<tr>
<td>1000</td>
<td>10.1</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1 pound-force per square inch = 6.8947 kPa

1114.9.4 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 1114.9.4(1).

\[
L = \frac{9 \cdot P_{a}^{2} \cdot d \cdot \ln\left(\frac{P_{a}}{P_{a0}}\right)}{C \cdot C_{r} \cdot f} \cdot \frac{d \cdot \ln\left(\frac{P_{a}}{P_{a0}}\right)}{d \cdot f}
\]

[Equation 1114.9.4(1)]

Where:
- \(C\) = Minimum required discharge capacity, pounds of air per minute.
- \(L\) = Equivalent length of discharge piping, inches 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 1112.12 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.
- \(d\) = Internal diameter of pipe or tube, inches.
- \(ln\) = Natural logarithm
\[ P_2 = \text{Absolute pressure at outlet of discharge piping, psia} \]

\[ P_0 = \text{Allowed back pressure (absolute) at the outlet of pressure relief device, (kPa)} \]

For relief valves and rupture disks:

[Equation 1114.9(2)]

\[ P = (\text{rated pressure in psig x 1.1}) + 14.7 \]

For fusible plugs, \( P = P_1 \)

\[ P_1 = \text{Absolute saturation pressure corresponding to the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, psia.} \]

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 1114.9.3):

For conventional relief valves: 15 percent of set pressure:

\[ P_0 = (0.15 \times P) + P_a \]  
[Equation 1114.9.4(2)]

For balanced relief valves: 25 percent of set pressure:

\[ P_0 = (0.25 \times P) + P_a \]  
[Equation 1114.9.4(3)]

For rupture disks alone: fusible plugs, and pilot operated relief devices, 50 percent of set pressure:

\[ P_0 = (0.50 \times P) + P_a \]  
[Equation 1114.9.4(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 15:9.7.9.3.1, 9.7.9.3.2]

1114.9.5 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 pressure at each relief device from exceeding the maximum allowable outlet pressure in accordance with Section 1114.9.4. [ASHRAE 15:9.7.9.3.3]

**SUBSTANTIATION:**

In 2000, ASHRAE updated the equation used to calculate the maximum allowable line length. The line length equation for pressure relief valves currently in the UMC is based on an old line length equation from ASHRAE 15-1994. The updated line length equation allows designers to properly engineer relief systems to ensure their safe operation by limiting the backpressure on relief valves to a level where their performance will not be adversely affected. Also, the old formulation cannot be used to properly analyze or engineer manifolded or headered relief systems. As such, the proposed changes are acute from a safety perspective. In addition, the proposed revisions would re-align the UMC with the current version of ASHRAE 15-2013 and “addenda a” to ASHRAE 15-2013.

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  AFFIRMATIVE: 21    NOT RETURNED: 1 Garza

**EXPLANATION OF AFFIRMATIVE:**

**CABOT:** While the comment adds extensive new provisions that were not specifically raised as part of the proposal, the subject topic is covered and therefore a public comment is appropriate and would not violate IAPMO/ANSI procedures.
Item # 296
UMC 2015 – (1121.2):

SUBMITTER: Jeffrey M. Shapiro

RECOMMENDATION:
Delete text without substitution:

1121.2 Power and Supervision. Detection and alarm systems shall be powered and supervised as required for fire alarm systems in the fire code.

(renumber remaining sections)

SUBSTANTIATION:
Section 1121.4 already requires installation, maintenance and testing of detection and alarm systems to be in accordance with the fire code. Refrigerant detection and alarm systems are regulated by fire codes as emergency alarm systems, as opposed to fire alarm systems, and the provisions in Section 1121.2 are inconsistent with the requirements for emergency alarms, which are typically handled with programmable logic controllers or dedicated refrigerant detection and alarm systems that are not consistent with fire alarm system equipment or features.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
This proposal was rejected in favor of Item # 295 which revises Section 1121.2 in accordance with NFPA 72.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:

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

SUBSTANTIATION:
The committee cited action on Item # 295 as a basis of rejecting this proposal; however, Item # 295 did not address the same concern. This public comment repeats the recommendation that Section 1121.2 be entirely deleted. There is no need for the section to be retained in the UMC, and maintaining it continues the current confusion by suggesting that refrigerant detection and alarm systems are required to be powered and supervised as fire alarm systems, when this shouldn’t be necessary. Refrigerant detection and alarm systems are regulated by fire codes as emergency alarms systems, as opposed to fire alarm systems, and the provisions in Section 1121.2 are inconsistent with the requirements for emergency alarms, which are typically handled with programmable logic controllers or dedicated refrigerant detection and alarm systems that are not consistent with fire alarm system equipment or features. Section 1121.4 already requires installation, maintenance and testing of detection and alarm systems to be in accordance with the fire code, and that reference is adequate.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report II Item # 173)

RECOMMENDATION:
Revise text as follows:

**1124.1 Factory Tests.** Refrigerant-containing parts of units **systems** shall be tested and proved tight by the manufacturer at **not less than** the design pressure for which they are rated. [ASHRAE 15:9.14.1] The test pressure applied to the high side of each factory-assembled refrigeration **system** shall be equal to **not less than** the design pressure of the high side. The test pressure applied to the low side of each factory-assembled refrigeration **system** shall be equal to **not less than** the design pressure of the low side. [ASHRAE 15:9.14.2]

Exception: Units with a design pressure of **not more than** 15 psig (103 kPa) or less shall be tested at a pressure not less than 1.33 times the design pressure. [ASHRAE 15:9.14.3]

SUBSTANTIATION:
Section 1124.1 is being revised to correlate with ASHRAE 15-2010. All other changes were done to comply with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

**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 fuse 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] Pressure vessels having inside dimension of 6 inches (152 mm) or less shall be protected by a pressure relief device or fusible plug.

**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 individually or as part of an assembly.
2. Marked directly on the vessel or on a nameplate attached to the vessel 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 design, fabrication, and testing requirements are 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 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]

(renumber remaining sections)

1124.1 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]

1124.1.1 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 allowed 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]

1124.1.2 Applied Pressure. The test pressure applied to the high-side of each factory-assembled refrigerating system shall be not less than the design pressure of the high-side. The test pressure applied to the low-side of a factory assembled refrigerating system shall be not less than the design pressure of the low-side. [ASHRAE 15:9.14.1.2]

1124.1.3 Design Pressure of 15 psig or Less. Exception: Units with a design pressure of not more than 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]

SUBSTANTIATION:
1. Section 1124.1 and Section 1113.1 are being modified to correlate completely with ASHRAE 15-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). The reason, in the original proposals, the language did not correlate with ASHRAE 15 is because Chapter 11 did not address provisions for pressure vessels used in a refrigeration system. However, Chapter 11 should address pressure vessels as pressure vessels are crucial components used in a refrigeration systems. Furthermore, Section 1001.1(6) refers the end user to Chapter 11 for pressure vessels used in a refrigeration system. For informational purposes only, Section 1001.1(6) is shown as follows: Pressure vessels used in refrigeration systems shall comply with Chapter 11. As of now Chapter 11 has no provisions for pressure vessels used in a refrigeration system, and therefore Section 1117.0 through Section 1117.3 are necessary to make the language in Section 1001.1(6) true.
2. Section 1113.2 is being revised as the text “Pressure vessels having inside dimension of 6 inches (152 mm) or less shall be protected by a pressure-relief device or fusible plug” is already addressed in Section 1117.1, and therefore redundant.

3. The extraction in Section 1124.1.2 is being deleted as the language does not correlate with ASHRAE 15-2013.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 21   NOT RETURNED: 1 Garza
Submitter: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 1)

Recommendation:
Revise text as follows:

1201.0 General.
1201.1 Applicability. This chapter shall apply to hydronic piping systems that are part of heating, cooling, ventilation, and air conditioning systems. Such piping systems include steam, hot water, chilled water, steam condensate, 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. The temperature of surfaces within reach of building occupants shall not exceed 140°F (60°C) unless they are protected by insulation. Where sleeves are installed, the insulation shall continue full size through them.

Coverings and insulation used for piping shall be of material approved for the operating temperature of the system and the installation environment. Where installed in a plenum, the insulation, jackets, and lap-seal adhesives, including pipe coverings and linings, shall have a flame-spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested in accordance with ASTM E84 or UL 723.

1201.3 Water Hammer. The flow of the hydronic piping system shall be controlled to prevent water hammer.

1201.3.2.11 Insulation. Coverings and insulation used for hot water pipes shall be of material approved for the operating temperature of the system. 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. The specimen preparation and mounting procedures of ASTM E2231 shall be used. Materials used for pipe coverings and insulation (including the insulation, jacket, and lap-seal adhesives) shall have a maximum peak heat release rate of 1.02 E+06 British thermal units per hour (Btu/h) (299 kW), a maximum total heat release of 4.7 E+04 Btu (50 MJ), a maximum total smoke release of 5382 square feet (500 m²), and shall not generate flames that extend 1 foot (305 mm) or more above the top of the vertical portion of the apparatus during the test where tested in accordance with NFPA 274. Insulation coverings and linings shall not flame, glow, smolder, or smoke where tested in accordance with ASTM C 411 at the temperature to which they are exposed in service. In no case shall the test temperature be less than 250°F (121°C).

1201.3.8.6 (A) Insulation. The temperature of surfaces within normal reach of building occupants shall not exceed 140°F (60°C) unless they are protected by insulation. Where sleeves are installed, an insulation shall continue full-sized through them.

1201.3.8.6 (B) Lining. Combustible portions of unventilated spaces that contain piping or devices whose outside temperature, including insulation, exceeds 140°F (60°C), shall be lined with No. 24 gauge (0.021 inch) (0.53 mm) steel, or 1/4 of an inch thick (6.4 mm) insulating millboard.

1201.4.1.2 Insulation. Coverings and insulation used for hot water pipes shall be of material approved for the operating temperature of the system. 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. The specimen preparation and mounting procedures of ASTM E2231 shall be used. Materials used for pipe coverings and insulation (including the insulation, jacket, and lap-seal adhesives) shall have a maximum peak heat release rate of 1.02 E+06 Btu/h (299 kW), a maximum total heat release of 4.7 E+04 Btu (50 MJ), a maximum total smoke release of 5382 square feet (500 m²), and shall not generate flames that extend 1 foot (305 mm) or more above the top of the vertical portion of the apparatus during the test where tested in accordance with NFPA 274. Insulation coverings and linings shall not flame, glow, smolder, or smoke where tested in accordance with ASTM C 411 at the temperature to which they are exposed in service. In no case shall the test temperature be less than 250°F (121°C).
The Radiant Panel Association (RPA) is a national chapter of IAPMO. The Radiant Panel Association (RPA) is an active international organization of professionals who share the desire to advance the understanding and acceptance of radiant and hydronic technologies. Chapter 12 was revised to specifically address hydronic systems including piping systems that are part of heating, ventilation and air conditioning systems. Such piping system shall include steam, hot water, chilled water, steam condensate and ground source heat pump systems.

Hydronic systems must be designed for flow velocities that minimize the occurrence and magnitude of water hammer. This is accomplished by the installation of shock-arrester devices where quick-closing valves are located. The intent of this section is to protect the system and its components from the possible destructive forces that result from the rapid deceleration of fluid flow. A quick-closing valve would be any type of solenoid-actuated valve, spring-loaded self-closing valve or any other device capable of instantaneously reducing flow from full flow to no flow.

The sources of information and recommendations for this chapter are included as follows:

8. See Fluid Handling, Inc. Expansion Tank Application 2012. Milwaukee, WI.
9. See Fluid Handling, Inc. Air Control Products and Applications 2012. Milwaukee, WI.
10. See Fluid Handling, Inc. Calculating Pump Head 2012. Milwaukee, WI.
12. See National Insulation Association. K-Value, U-Value, C-Value; Understanding the Value in all these Values 2012. Reston, VA.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates

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

1201.4 Manifolds. Manifolds shall be equipped with a fullway isolation valve that is fully sealed on the supply and return lines. Manifolds shall be capable of withstanding the pressure and temperature of the system. The material of the manifold shall be compatible with the system fluid and shall be installed in accordance with the manufacturer’s installation instructions.

1201.5 Heat Emitters. Heat emitters shall be installed in accordance with the manufacturer’s installation instructions.

SUBSTANTIATION:
Manifolds are mainly used to control separate zones and are required for systems that require more than one water temperature. It is crucial to maintain manifolds in proper working conditions, thus requiring isolation valves for serv-
icing and maintenance. Valves of fullway-type are preferred as they permit for full flow of the fluid. However, regardless if a fullway valve is used, they must be full sealing to allow the valve to fully open and fully closed.

Heat emitters such as finned-tube baseboards convectors, fan-coil convectors, or panel radiators shall be installed in accordance with the manufacturer’s installation instructions.

Furthermore, the Section 1201.4 and Section 1201.5 will correlate with similar provisions proposed for the 2015 USEHC, which was accepted by the USEHC Technical Committee.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (new topic under Section 1201.4 and Section 1201.5) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:

“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”

TAYLOR: The addition says basically nothing and is unnecessary.

PUBLIC COMMENT 2:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

210.0

Hydronics. Of or relating to a heating or cooling system that transfers energy by circulating a fluid through a system of pipes or tubing.

SUBSTANTIATION:
The term “hydronics” is referenced throughout Chapter 12 without being defined. The proposed definition assists the end user in applying and enforcing this term.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza
EXPLANATION OF NEGATIVE:

CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure Section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (new definition 210.0 - Hydronics) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”

PUBLIC COMMENT 3:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.
Some examples of issues are:
(1) In Section 1201.1, the scope does not list condenser water systems, nor are they addressed anywhere in the proposed text.
(2) In Section 1201.3, the language is unenforceable. How does the engineer or code official know that the design complies?

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1. Furthermore, there was no technical justification provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The following Section numbers should be revised as follows:
1201.0 General.
1201.1 Applicability. This chapter shall apply to hydronic steam and water piping systems that are part of heating, cooling, ventilation, and refrigeration air conditioning systems. Such piping systems include steam, hot water, chilled
water, steam condensate, 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. The temperature of surfaces within reach of building occupants shall not exceed 140°F (60°C)
unless they are protected by insulation. Where sleeves are installed, the insulation shall continue full size through
them.

Coverings and insulation used for piping shall be of material approved for the operating temperature of the sys-
tem 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.

4201.2 Water Hammer. The flow of the hydronic piping system shall be controlled to prevent water hammer.

Rationale:

• “Steam and water” is used instead of repeating “hydronic” since many people think of “hydronic” only as water. This
  is also what the current language says.

• “Refrigeration” is used in place of “air conditioning” to match the scope in Section 101.3. So this chapter would then
  also apply to condenser water systems used for industrial refrigeration processes.

• The examples listed are not necessary and leave out open condenser water systems, closed condenser water
  systems, and perhaps some others. There is no reason to list examples; the current requirement does not include
  a list and no confusion has resulted.

• The last sentence of Section 1201.1 is simply unnecessary.

• Section 1201.3 language is unenforceable. How does the engineer or code official know that the design com-
  plies?
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 2)

RECOMMENDATION:
Add new text as follows:

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. Where materials in the hydronic system are not suitable for use in a potable water system, such potable water shall not be used. 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

SUBSTANTIATION:
Any fluid having the potential of imposing more than a minor or moderate hazard to the potable water supply must be separated by a double wall heat exchanger. Typically, two kinds of antifreeze are used in hydronic systems, ethylene or propylene which is toxic; therefore the potable water must be protected. In addition, the materials used to construct the system must be compatible with the chemicals used. There must be an acceptable method of protecting the potable water systems that interface with these systems. The method of protection is relative to the hazard imposed by the chemicals. Employing these considerations is in the best interest of public health and safety.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) In Section 1202.0, the protection of potable water is covered in the plumbing code and in Section 315.1 per Item # 316.
(2) In Section 1202.3, it appears to not allow nonpotable systems to be filled with potable water, and it appears to outlaw double wall heat exchangers.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
Any fluid having the potential of imposing more than a minor or moderate hazard to the potable water supply must be separated by a double wall heat exchanger. Typically, two kinds of antifreeze are used in hydronic systems, ethylene or propylene which is toxic; therefore the potable water must be protected. In addition, the materials used to construct the system must be compatible with the chemicals used. There must be an acceptable method of protecting the potable water systems that interface with these systems. The method of protection is relative to the hazard imposed by the chemicals. Employing these considerations is in the best interest of public health and safety.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• The UMC does not address potable water systems. That is left to the plumbing code which does so in detail. There is no need to address it in the UMC. Note that the prior Chapter 12 did not address potable water systems at all suggesting there is no reason to start now.
• In Section 1202.0, the protection of potable water is covered in the plumbing code and in Section 315.1 which refers to the plumbing code.
• In Section 1202.3, it appears to not allow nonpotable systems to be filled with potable water, and it appears to outlaw double wall heat exchangers.
RECOMMENDATION:
Add new text as follows:

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 both, to supply potable hot water and provide hot water for space heating shall be listed or labeled, 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.

1203.3 Tankless Water Heater. The output performance on tankless water heaters 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.

SUBSTANTIATION:
The heat source is sized to satisfy all loads that will occur simultaneously unless the heat source output is designed to alternate either heating or domestic production. The heat source is sized to meet the greater of the loads since the loads are not imposed on the heat source at the same time. Where the additional heat loads are determined to be seasonal, the heat source must be size to the largest load that will be imposed on it. The intent is to ensure a correctly sized heat source.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:

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

1203.2 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. 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>Electric, Household</td>
<td>UL 174</td>
</tr>
<tr>
<td>Oil fired Storage Tank</td>
<td>UL 732</td>
</tr>
<tr>
<td>Gas, 75 000 Btu/h or less</td>
<td>CSA Z21.10.1</td>
</tr>
<tr>
<td>Gas, Above 75 000 Btu/h</td>
<td>CSA Z21.10.3</td>
</tr>
<tr>
<td>Gas, Commercial</td>
<td>UL 795</td>
</tr>
<tr>
<td>Electric, Commercial</td>
<td>UL 1453</td>
</tr>
<tr>
<td>Electric, Space Heating</td>
<td>UL 834</td>
</tr>
<tr>
<td>Solid Fuel</td>
<td>UL 2523</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293kW
1207.2 Boilers. Oil-fired boilers and their control systems shall comply with Section 1002.2.1, 1002.0. Electric boilers shall comply with Section 1002.3. Solid-fuel-fired boilers shall comply with UL 2523. Boilers shall be designed and constructed in accordance with Section 1002.1.

1207.3 Dual-Purpose Water Heaters. Water heaters used for combined space- and water-heating applications shall be in accordance with CSA Z21.10.1 or CSA Z21.10.3 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.

SUBSTANTIATION:
In Section 1207.2, the text was modified to refer to the existing requirements in Section 1002 for boiler requirements rather than repeating text in this section.

In Section 1203.2 and Section 1207.3, the text was modified, and Table 1203.2 was added, to clarify the listing requirements for water heaters that correlate with the UPC (Item # 155). Item # 155 of the UPC was accepted with modifications, which eliminated UL 834 for electric space heating heaters because UL 834 was not within the scope of the UPC. However, UL 834 is within the scope of the UMC and should be included in this table. Furthermore, UL 732, UL 795, UL 1453, UL 834, and UL 2523 have already been proposed in Item # 197. Lastly, CSA Z21.10.1, CSA Z21.10.3, and UL 2523 are being relocated to Table 1203.2 from Section 1207.2 and Section 1207.3.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

Amend comment as follows:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric, household</td>
<td>UL 174</td>
</tr>
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<td>Oil-fired storage tank</td>
<td>UL 732</td>
</tr>
<tr>
<td>Gas, 75,000 Btu/hr or less</td>
<td>CSA Z21.10.1</td>
</tr>
<tr>
<td>Gas, above 75,000 Btu/hr</td>
<td>CSA Z21.10.3</td>
</tr>
<tr>
<td>Gas, commercial</td>
<td>UL 705</td>
</tr>
<tr>
<td>Electric, commercial</td>
<td>UL 1453</td>
</tr>
<tr>
<td>Electric, space heating</td>
<td>UL 834</td>
</tr>
<tr>
<td>Solid fuel, hydronic</td>
<td>UL 2523</td>
</tr>
</tbody>
</table>

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

1002.4 Solid-Fuel Boilers. Solid-fuel boilers shall comply with UL 2523 and installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
1. UL 174 and 732 are out of the scope of the UMC as Section 1001.1 indicates that the UMC applies to boilers and pressure vessels that exceed 120 gallons. Therefore, it should be addressed in the UPC and not the UMC.
2. UL 795 is applicable to appliances such as furnaces and air heaters. It is not applicable to water heaters. UL 795 does not address water heaters. Furthermore, Item # 155 of the UPC removed such standard from the UPC as it did not addressed water heaters.
3. Chapter 10 of UL 1453 indicates that the water heater addressed within the standard are not intended for space heating. Therefore, out of the scope of the UMC.
4. UL 2523 should also be addressed in Chapter 10 as it is an applicable standard for solid-fuel boilers for other than just hydronic systems.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
CABOT: While the comment includes sections not part of this proposal (#307), other proposals did include the sections and therefore received a public review.

CARROLL: The inclusion of this table is important for the clear understanding of the code and for the correlation with the UPC. That said, there were a couple of standards amended out of the table which should be part of the table.

Water heaters when used for space heating purposes are within the scope of the UMC. The name of the section that references this table is “Dual Purpose Water Heater.” UL 174 and UL 732, which cover water heaters, would be out of the scope of the UMC if used for water heating purposes only, but should be included in this table for products that are used as a heating source for space heating.

In addition, the scope of UL 795 covers water heaters and boilers as well as furnaces and air heaters which are gas fired (The scope of the standard is shown below). As such, UL 795 should be included in this table. The reason it was deleted from Item #155 for the UPC was the misunderstanding that this standard included boilers only and not water heaters. That was not true. UL 795 should be included in this table.

For informational purposes only. The scope as stated in UL 795 is shown as follows:

INTRODUCTION

1 Scope

1.1 These requirements apply to factory-built gas appliances having inputs of more than 400,000 Btu per hour, per individual combustion chamber which require flame failure and other precautions and which are intended primarily for commercial and industrial installation. The appliances covered by these requirements are comfort heating furnaces, heaters and gas-fired boiler assemblies except watertube boilers having outputs of 10,000 pounds of steam per hour or more.

1.1.1 These requirements also apply to all high pressure steam and high temperature water gas-fired boiler assemblies regardless of Btu per hour input.

1.2 Gas-heating equipment covered by these requirements may be operated without a competent attendant being constantly on duty at the burners while the appliances are in operation.

1.3 Additional installation and operation requirements are available for central-heating gas appliances, floor furnaces, room heaters, unit heaters, and water heaters as defined by the National Fuel Gas Code, NFPA 54, and by the Liquefied Petroleum Gas Code, NFPA 58, as applicable.

EXPLANATION OF NEGATIVE:
TAYLOR: The section on dual purpose water heaters should be moved into Chapter 10 where all other heating equipment is addressed. It does not belong in Chapter 12.

PUBLIC COMMENT 2:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) In Section 1203.0, the language is unenforceable, particularly Section 1203.1 and Section 1203.3.
(2) In Section 1203.2, it requires that the capacity of dual purpose systems be the sum of space heating and domestic water loads. However, this is not necessary for many commercial systems since the two loads peak at very different times. This unnecessarily increases costs and energy due to oversized boilers.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1. Furthermore, there was no technical justification provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
OWENS: I agree with the comments submitted by Maggie Carroll for Public Comment 1.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 4)

RECOMMENDATION:
Add new text as follows:

**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.

**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.

**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>¼ to ½</td>
<td>8</td>
<td>½</td>
</tr>
<tr>
<td>½ to 1½</td>
<td>8</td>
<td>½</td>
</tr>
<tr>
<td>1½ to 2</td>
<td>8</td>
<td>½</td>
</tr>
<tr>
<td>2½ to 6</td>
<td>12</td>
<td>1½</td>
</tr>
<tr>
<td>8 to 10</td>
<td>24</td>
<td>2½</td>
</tr>
<tr>
<td>Over 10</td>
<td>32</td>
<td>3½</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

SUBSTANTIATION:
Identification of the water supply system is critical to the safe functioning of the building and the protection of the occupants of that building. The system cannot be compromised in any fashion. The first step in the protection of the water supply is the correct labeling of various water systems in the building. This is important during construction but also especially after the building is occupied when it is subject to maintenance or additions. The requirements above must be adhered to on every installation where potable and nonpotable water systems are present.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Michael Cudahy, Plastic Pipe and Fittings Association (PPFA)

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
1204.4 Nonpotable Water. Nonpotable water systems shall have a yellow purple 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.

SUBSTANTIATION:
Yellow piping is typically understood to be fuel gas piping and an extreme hazard if an accident occurs. Purple pipe is the standard color for nonpotable water of multiple types and sources and is commercially available. PPFA recommends a modification to indicate purple and not yellow.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed color “purple” is not consistent with the UPC. Purple is for alternate water sources in the UPC.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 2:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the identification of potable and nonpotable water systems. Furthermore, there was no technical substantiation provided as to why the identification requirements are unsafe for the public’s health and safety.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: Identification of potable and nonpotable domestic water is covered in the plumbing code and this is almost (but not quite) a verbatim copy. This is the mechanical code and by definition it does not cover the installation of potable water piping. Having this here does nothing but create a possible conflict with the plumbing code.
UMC 2015 – (1205.0 – 1205.4):

SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 5)

RECOMMENDATION:
Revise text as follows:

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.
1205.3 Flushing. Heat sources, system piping and tubing shall be flushed after installation with water or a cleaning solution. Cleaning of the heat source 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. The heat source shall be disconnected from the piping system or protected with a fine mesh strainer during flushing to prevent debris from being deposited into the heat source.
1205.4 Oxygen Diffusion Corrosion. PEX, PE-RT, and PB tubing in closed hydronic systems shall contain an oxygen barrier.

1201.3.9 Pressure Testing. The equipment, material, and labor necessary for inspection or test shall be furnished by the person to whom the permit is issued or by whom inspection is requested.
1201.3.9.1 Media. The piping shall be tested with water.
1201.3.9.2 Pressure Test. Piping shall be tested with a hydrostatic pressure of not less than 100 psig (689 kPa), and 50 psig (345 kPa) more than the operating pressure. This pressure shall be maintained for not less than 30 minutes. Required tests shall be conducted by the owner or contractor in the presence of an authorized inspector. The piping being tested shall remain exposed to the inspector and shall not leak during the test.
1201.3.9.3 Moved Structures. Piping systems of a building and parts thereof that are moved from one foundation to another shall be 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 are provided.
1201.3.9.4 Test Waived. No test or inspection shall be required where a system, or part thereof, is set up for exhibition purposes and has no connection with a water system.
1201.3.9.5 Exceptions. In cases where it is impractical to provide the aforementioned tests, or for minor installations and repairs, the Authority Having Jurisdiction shall have the authority to make such inspection as it deems necessary.

1207.0 Testing.
1207.1 General. Approved piping or tubing installed as a portion of a radiant panel system that will be embedded in the walls, floors, or ceilings of the building it is designed to heat shall be tested for leaks by the hydrostatic test method by applying not less than 100 psi (689 kPa) water pressure or one and one half times the operating pressure, whichever is greater. For metal piping, a pressure gauge shall be connected to the piping, and after the pressure has been raised, the hydrostatic pressure connection shall be disconnected and the systems under pressure shall remain at the test pressure for a period of time to determine whether leaks exist in the system. A leak shall be indicated by the pressure drop on the gauge. The test period shall be not less than 30 minutes.

For flexible plastic piping, the test pressure shall be applied for a period of 30 minutes. During this time, the system shall be maintained at the test pressure by the periodic addition of makeup water to compensate for the initial stretching of the pipe. The system shall be visually inspected for tightness. Tests for tightness of radiant piping systems shall be witnessed by the Authority Having Jurisdiction.
SUBSTANTIATION:
It is imperative that operating and maintenance manuals are provided to the building owner in order to properly operate and maintain the system for future reference. System piping must be tested in order to verify there are no leaks before placing into service and capable of withstanding system operating pressures. This pressure will typically coincide with the set point pressure of the system’s pressure relief devices.

System flushing after installation will eliminate debris from the piping. The cleaning or flushing solution specifically designed for the system will remove fluxes and oils that are still in the system.

Tubing made from thermoplastics allows oxygen molecules to slowly pass through the tube wall and enter the water in the system. This process is called oxygen diffusion. Oxygen corrosion is a very serious corrosion problem in hydronic systems. The dissolved oxygen present in the water when the system is first filled quickly reacts with any iron or steel components. The rate of oxygen diffusion varies for different materials and higher temperatures. The solution to this problem is to create an oxygen diffusion barrier in or on the tubing. One such barrier is a thin layer of a special compound called EVOH (ethylene vinyl alcohol) that is bonded to the tubing during manufacturing. Another type of oxygen barrier is a thin layer of aluminum sandwiched between layers of PEX-AL-PEX. The use of oxygen barrier-equipped tubing does not guarantee that oxygen-related corrosion will not occur. There are several other ways for oxygen to enter a hydronic system such as improperly sized or placed expansion tank, leaky valve seals or pump gaskets, and improperly located air vents. See Code Review Task Group Report 1, Item # 5 where sections are deleted based on duplication of text in the UMC.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:

SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.
Some examples of issues are:
(1) In Section 1205.3, it addresses heat sources but not other equipment that may be part of the system, e.g. chillers. This chapter does not just apply to hot water systems which clearly is the bias of the author(s).
(2) Section 1205.4 is in the wrong location as it has nothing to do with this section, and it needs to be relocated to the piping material section.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
It is imperative that operating and maintenance manuals are provided to the building owner in order to properly operate and maintain the system for future reference. System piping must be tested in order to verify there are no leaks before placing into service and capable of withstanding system operating pressures. This pressure will typically coincide with the set point pressure of the system’s pressure relief devices.
System flushing after installation will eliminate debris from the piping. The cleaning or flushing solution specifically designed for the system will remove fluxes and oils that are still in the system.

Tubing made from thermoplastics allows oxygen molecules to slowly pass through the tube wall and enter the water in the system. This process is called oxygen diffusion. Oxygen corrosion is a very serious corrosion problem in hydronic systems. The dissolved oxygen present in the water when the system is first filled quickly reacts with any iron or steel components. The rate of oxygen diffusion varies for different materials and higher temperatures. The solution to this problem is to create an oxygen diffusion barrier in or on the tubing. One such barrier is a thin layer of a special compound called EVOH (ethylene vinyl alcohol) that is bonded to the tubing during manufacturing. Another type of oxygen barrier is a thin layer of aluminum sandwiched between layers of PEX-AL-PEX. The use of oxygen barrier-equipped tubing does not guarantee that oxygen-related corrosion will not occur. There are several other ways for oxygen to enter a hydronic system such as improperly sized or placed expansion tank, leaky valve seals or pump gaskets, and improperly located air vents.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The following sections should be revised as follows:
1205.0 Installation, Testing, and Inspection Flushing.
1205.1 Operating Instructions. Operating and maintenance information shall be provided to the building owner.
1205.12 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.
1205.23 Flushing. Heat sources. System piping and tubing shall be flushed after installation with water or a cleaning solution. Cleaning of the heat source 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. The heat source shall be disconnected from the piping system or protected with a fine mesh strainer during flushing to prevent debris from being deposited into the heat source.
1205.4 Oxygen Diffusion Corrosion. PEX, PE-RT, and PB tubing in closed hydronic systems shall contain an oxygen barrier.

Rationale:
• Operating instructions are addressed in Section 303.2 and there are no operating instructions for hydronic piping systems anyway.
• “Heat sources” are eliminated from the “flushing” section because this section does not just apply to heating systems and in general equipment does not need to be protected during cleaning; the water paths through boilers, chillers, etc. are similar to piping.
• The “oxygen barriers” paragraph has nothing to do with testing and cleaning. Furthermore, oxygen barrier PEX is typically used in hydronic heating applications only where cast iron or other ferrous components are present in the system. It is not needed in other systems. It is in particular not needed for open systems such as cooling towers since the water is already oxygenated. The need should be determined by the engineer. A general requirement for oxygen barriers is too stringent.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 6)

RECOMMENDATION:
Add new text as follows:

1206.0 Safety Devices.
1206.1 General. Hydronic systems containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with a pressure and temperature relief valve. Each section of the system in which excessive pressures are capable of developing shall have a relief valve located so that a section is not capable of being isolated from a relief device. Pressure and temperature relief valves shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

1206.2 Pressurized Vessels. Pressurized vessels shall be provided with overpressure protection by means of a listed pressure relief valve installed in accordance with the manufacturer’s installation instructions.

1206.3 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall have no valves, obstructions or means of isolation and be provided with the following:

(1) 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 terminate to the floor, waste receptor, or to the outdoors. The end of the pipe shall not terminate more than 6 inches (152 mm) above the floor or waste receptor, or extend to the outdoors not less than 6 inches (152 mm) and not more than 24 inches (610 mm) aboveground.
(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.

SUBSTANTIATION:
Any heated closed system is capable of developing pressures that exceed its design working pressure. Closed liquid-filled systems can develop high hydrostatic pressures with even slight temperature increases. A hydronic system is more likely to be subjected to extreme temperatures and pressures that could cause system failures and the associated hazards. Pressure and temperature relief valves are necessary to prevent injury and property damage that could result from the failure of pressurized vessels and piping. Typical hydronic systems involve large complex piping circuits with valve arrangements that greatly increase the likelihood of portions of the piping system being isolated from the over-pressure or over-temperature safety devices. Any portion of a system isolated from the relief valve or valves is unprotected from the danger of excessive pressures and temperatures. To ensure complete protection to all portions of a system, multiple relief valves at different locations in the system may be necessary. Safety or relief valve discharge pipe is designed to direct the discharge to a location where it cannot cause injury or property damage. The material from which the discharge pipe is constructed must be able to withstand such pressures and temperatures, as well as be able to resist the forces developed during discharge that would tend to dislocate the discharge pipe. If a discharge pipe were smaller in its internal cross-sectional area than the safety or relief valve outlet, the resulting restriction would reduce the relieving capacity, thereby adversely affecting the operation of the device. Because the discharge from any safety or relief valve is a threat to both the building and its occupants, each installation must be individually evaluated to prevent the potential discharge from being hazardous.

COMMITTEE ACTION: Accept as Submitted
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

1206.1 General. Hydronic systems containing pressurized fluids, during normal operation, shall be protected against pressures and temperatures exceeding design limitations with a pressure and temperature relief valve. Each section of the system in which excessive pressures are capable of developing shall have a relief valve located at the heat source so that a section is not capable of being isolated from a relief device. Pressure and temperature relief valves shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

SUBSTANTIATION:
Potable water storage tanks are required to have a temperature and pressure relief valve installed as a part of their safety package. True closed loop hydronic systems require the use of a pressure relief valve only. Over temperature protection is provided by the onboard safety controls that are controlling the heat source. In many cases, the boiler fluids can safely operate over 210°F, which would cause the thermostatic portion of a T&P relief valve to actuate and causing an unnecessary loss of fluids. Safety relief valves are typically located near the outlet of the energy source, whatever it may be. The requirement to have pressure relief valves, where there are isolation valves, will significantly add cost to the heating system because a floor drain and associated plumbing with that device to safely receive and dispose of discharging fluids must be installed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed language lacks technical substantiation to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The commenter is correct. The typical hydronic system is protected with pressure relief valves.

PUBLIC COMMENT 2:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

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Some examples of issues are:

1. In Section 1206.1, it appears to require pressure relief valves (PRV) everywhere on a cooling system; they can warm and water can expand in any section. The chapter was written as if all systems were heating systems.

2. In Section 1206.2, it also requires PRVs at every “vessel,” which apparently includes expansion tanks, air separators, pot feeders, etc. Chapter 9 and Chapter 10 already address pressure relief valves so Section 1206.0 is redundant, at least for heating systems.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
Any heated closed system is capable of developing pressures that exceed its design working pressure. Closed liquid-filled systems can develop high hydrostatic pressures with even slight temperature increases. A hydronic system is more likely to be subjected to extreme temperatures and pressures that could cause system failures and the associated hazards. Pressure and temperature relief valves are necessary to prevent injury and property damage that could result from the failure of pressurized vessels and piping. Typical hydronic systems involve large complex piping circuits with valve arrangements that greatly increase the likelihood of portions of the piping system being isolated from the over-pressure or over-temperature safety devices. Any portion of a system isolated from the relief valve or valves is unprotected from the danger of excessive pressures and temperatures. To ensure complete protection to all portions of a system, multiple relief valves at different locations in the system may be necessary. Safety or relief valve discharge pipe is designed to direct the discharge to a location where it cannot cause injury or property damage. The material from which the discharge pipe is constructed must be able to withstand such pressures and temperatures, as well as be able to resist the forces developed during discharge that would tend to dislocate the discharge pipe. If a discharge pipe were smaller in its internal cross-sectional area than the safety or relief valve outlet, the resulting restriction would reduce the relieving capacity, thereby adversely affecting the operation of the device. Because the discharge from any safety or relief valve is a threat to both the building and its occupants, each installation must be individually evaluated to prevent the potential discharge from being hazardous.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The following sections should be revised as follows with changes from original shown tracked:

1206.0 Pressure Safety Devices.

1206.1 General. Each closed hydronic system containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with at least one pressure and temperature relief valve. Each section of the system in which excessive pressures are capable of developing containing heating equipment shall have a relief valve located so that a section of the equipment is not capable of being isolated from a relief device. Pressure and temperature relief valves shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

1206.2 Pressurized Vessels. Pressurized vessels shall be provided with overpressure protection by means of a listed pressure relief valve installed in accordance with the manufacturer’s installation instructions.

1206.23 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall be installed as follows:

(1) No valves, obstructions, or means of isolation shall be installed between the relief valve and the heat producing device, nor on the discharge pipe between the safety valve and the atmosphere, and be provided with the following:

(2) Pipe size shall be equal to the size of the valve outlet and shall discharge full size to the termination flood level of the area receiving the discharge and pointing down.

(3) Materials shall be rated at not less than the operating temperature of the system and approved for such use.

(4) Discharge pipe shall terminate to the floor, waste receptor, or to the outdoors, pointing down. The end of the pipe shall not terminate more than 6 inches (152 mm) above the floor or waste receptor, or extend to the out-
doors not less than 6 inches (152 mm) and not more than 24 inches (610 mm) above ground. Where the operating temperature is in excess of 212°F (100°C), shall be equipped with a splash shield or centrifugal separator.

(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.

**1206.3 Vacuum Relief Valve.** Hydronic 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.

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220.0

**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.

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**1006.0 Safety or Relief Valve Discharge.**

**1006.1 General.** The discharge from relief valves shall be piped to within 18 inches (457 mm) of the floor or to an open receptacle, and where the operating temperature is in excess of 212°F (100°C), shall be equipped with a splash shield or centrifugal separator. Where the discharge from safety valves would result in a hazardous discharge of steam inside the boiler room, such discharge shall be extended outside the boiler room. No valve shall be placed between the safety or relief valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. Discharges from relief valves on industrial boilers shall be discharged to an approved location.

Rationale:

- Temperature relief is eliminated. Temperature is an indirect measure of pressure which is the safety issue here. Temperature relief is not needed on hydronic systems and seldom if ever installed. See also Public Comment 1 to Item # 310.
- As written, Section 1206.1 would require pressure relief valves everywhere that can be isolated on a cooling system; they can warm and water can expand in any section. This does not result in failure because the valves will leak enough to keep pressure below construction limits. The language was revised so that any heat producing equipment had to have a valve that could not be isolated.
- In Section 1206.2, it also requires PRVs at every “vessel,” which apparently includes expansion tanks, air separators, pot feeders, etc. This is not needed. This section is deleted because Section 1206.1 now addresses valves at heat producing equipment and Chapter 9 and Chapter 10 address valves at equipment where needed.
- Relief valves are addressed in Sections 1006.1 which only addresses heating systems. Relief valves are needed on all closed hydronic systems in case of temperature rise. That section is deleted since it is not needed, except I moved some of the language into items 1 (more detail about where valves cannot go) and 4 (high temperature splash guards).
- In Item 4 regarding “personal injury or structural damage” is vague and not enforceable and basically the requirements of this section are spelling out how to discharge the relief in a manner that does not cause injury or damage.
- Vacuum relief was added as recommended in Item # 231 to be consistent with the USEHC. It is located in Chapter 12 rather than in Chapter 10 to be more general; vacuum can also occur in closed systems other than heating systems, e.g. those drained for freeze protection.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 7)

RECOMMENDATION:
Revise text as follows:

1207.0 Heating Appliances and Equipment.
1207.1 General. Heating appliances, equipment, safety and operational controls shall be listed for its intended use in a hydronic heating system and installed in accordance with the manufacturer’s installation instructions.
1207.2 Boilers. Oil-fired boilers and their control systems shall be listed or labeled in accordance with Section 1002.2.1. Electric boilers shall be listed or labeled in accordance with Section 1002.3. Solid-fuel-fired boilers shall be listed or labeled in accordance with UL 2523. Boilers shall be designed and constructed in accordance with Section 1002.1.
1207.3 Dual-Purpose Water Heaters. Water heaters used for combined space- and water-heating applications shall be listed or labeled in accordance with CSA Z21.10.1 or CSA Z21.10.3.
1207.3.1 Temperature Limitations. Where a combined space- and water-heating application requires water for space heating at temperatures exceeding 140°F (60°C), a thermostatic mixing valve that is listed or labeled in accordance with ASSE 1017 shall be installed to temper the water supplied to the potable water distribution system to a temperature of 140°F (60°C) or less.

1206.0 Heat Sources.
1206.1 General. Heat sources for generating hot water for use in hydronic panel radiant heating systems shall include conventional fossil fuel, hot water boilers, electrical-resistance heated boilers, air/water or water/water heat pumps, or solar heat collector systems. A latter system shall be permitted to include booster or backup heating units.
Systems shall be protected by pressure-temperature relief valves as outlined in this code.

SUBSTANTIATION:
Regulatory requirements for the approval and installation of pressure vessels are the same as for the approval of all other mechanical equipment and appliances, and must be designed and constructed in accordance with the respective referenced standard. When a heating appliance, equipment, safety and operational controls are tested in order to obtain a listing, the certification agency installs the equipment in accordance with the manufacturer’s installation instructions. The equipment is then tested under these conditions; thus, the installation instructions become an integral part of the listing and labeling process. Manufacturer’s installation instructions are thoroughly evaluated by the listing and certification agency to establish that a safe installation is prescribed. The listing and certification agency can require the manufacturer to alter, delete, or add information in the installation instructions as necessary to achieve compliance with the applicable standards and code requirements. The manufacturer’s installation instructions must be available to the Authority Having Jurisdiction because they are an enforceable extension of the code and are necessary for determining that the equipment has been properly installed. The listing and labeling process indicates that the equipment and its installation instructions are in compliance with applicable standards. Therefore, an installation in accordance with the manufacturer’s installation instructions is required.

Scalding accidents can easily occur when the potable hot water exceeds a temperature of 140°F (60°C). A temperature actuated mixing valve is required to limit the temperature of hot water to be used for bathing and other domestic purposes to 140°F (60°C) or less when the water heater is used for both potable hot water and hot water for space heating. Regardless of the water supply demand downstream from the valve or supply pressure fluctuations upstream from the valve, the user will be provided some protection from scalding injury because the temperature of the water supplied will not exceed 140°F.

COMMITTEE ACTION: Accept as Submitted
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates

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

1207.2.1 Condensing Boilers. A condensing boiler, in which the heat exchanger and venting system are designed to operate with condensing flue gases, shall be permitted to be connected directly to the panel heating system without a protective mixing device.

1207.2.2 Noncondensing Boilers. Where the heat exchanger and venting system are not designed to operate with condensed flue gases, the boiler shall be permitted to connect directly to the panel heating system where protected from flue gas condensation. The operating temperature of the boiler shall be more than the fluid temperature in accordance with the manufacturer’s instructions.

SUBSTANTIATION:
Condensing boilers allow the flue gas to condense. The condensation occurs on the heating surface of the heat exchanger and venting system. Therefore, the heat exchanger and venting system must be designed to operate with condensing flue gases.

Where a noncondensing boiler is used, corrosion will occur when the flue gases are cooled below the dew point and come in contact with a material that is not corrosion resistant. To avoid corrosion, heating systems should be designed to operate in a way that ensures a minimum return water temperature. It is important to verify that the minimum required return water temperature is in accordance with the manufacturer’s instructions to avoid corrosion.

Furthermore, the Section 1207.2.1 and Section 1207.2.2 will correlate with similar provisions proposed for the 2015 USEHC, which was accepted by the USEHC Technical Committee.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
ADLER: I agree with Harvey Kreitenberg’s substantiation.

TAYLOR: This should not be limited to "panel" systems. Condensing in non-condensing boilers can be an issue in all HW systems.

EXPLANATION OF NEGATIVE:
CABOT: The comment violates IAMPO’s Regulations Governing Committee Projects procedure section 4-4.2 Subjects Appropriate for Comment since the comment introduces a new substantive change (new coverage under Section 1207.2.1 and Section 1207.2.2) not published in the ROP as part of the proposal being commented on. The Committee must either vote to reject or hold this comment. If the comment is approved, the substantive change would not have had a public review in violation with ANSI Essential Requirements in section 2.5.2 Public Review.

ANSI defines a substantive changes as follows:
“Substantive Change: A substantive change in a proposed American National Standard is one that directly and materially affects the use of the standard. Examples of substantive changes are below:
- “shall” to “should” or “should” to “shall”;
- addition, deletion or revision of requirements, regardless of the number of changes;
- addition of mandatory compliance with referenced standards.”

PUBLIC COMMENT 2:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

1207.3 Dual-Purpose Water Heaters. Water heaters used for domestic water shall be permitted to be used for hydronic space heating, provided that a heat exchanger is used to separate the domestic water from the closed side of the system used for the hydronic heating system. Water heaters used for combined space- and water-heating applications shall be listed or labeled in accordance with CSA Z21.10.1 or CSA Z21.10.3.

SUBSTANTIATION:
As currently allowed under the provisions of Section 1207.3, combination potable water heating/space heating appliances are creating an unhealthy and unsanitary condition in the distribution piping systems. It is a known fact that Legionella Pneumophila bacteria will survive and thrive in the piping systems during non-space heating periods. If the bacteria are inhaled by the end user, and their immunity systems are compromised, the end user will contract Legionnaires disease. According to the Center for Disease Control, Legionella disease is commonly misdiagnosed as bacterial pneumonia. Furthermore, providing “flushing” does not stop this bacterial action.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The substantiation lacks technical justification to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 3:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) Section 1207.0 is largely or entirely redundant since heating appliances are already addressed in Chapter 9 and Chapter 10.
In Section 1207.3.1, it requires a mixing valve for control of DHW, but combined systems using a separate heat exchanger must be controlled with a control valve on the HHW side of the HX.

**COMMITTEE ACTION:** Reject the public comment

**COMMITTEE STATEMENT:**
The public comment removes provisions that are necessary for the enforcement of heating appliances and equipment used in hydronic systems. Furthermore, there was no technical justification provided to warrant the change.

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**
- **AFFIRMATIVE:** 20
- **NEGATIVE:** 1
- **NOT RETURNED:** 1 Garza

**EXPLANATION OF NEGATIVE:**
**TAYLOR:** I am voting negative for the following reasons:
- Equipment is already covered in Chapter 9 and Chapter 10. Nothing substantive is added here that is not already addressed.
- Temperature limitations for potable water systems are addressed in the plumbing code. For dual systems, this chapter only applies to the hydronic system; the plumbing code must be used for the domestic water side of the system.
- Section 1207.3.1 requires a mixing valve for control of DHW, but combined systems using a separate heat exchanger must be controlled with a control valve on the HHW side of the HX. This requirement is technically incorrect.
SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 8)

RECOMMENDATION:
Add new text as follows:

1208.0 Circulators.

1208.1 General. Circulators shall be listed for its intended use based on the heat transfer medium. Circulators shall be installed to allow for service and maintenance. Manufacturer’s installation instructions shall be followed for correct orientation and installation.

1208.2 Mounting. Where the installation of a circulator will cause strain on the piping, the circulator shall be supported in a manner that will eliminate strain on the piping. Where means for controlling vibration of a circulator is required, an approved means for support and restraint shall be provided.

1208.3 Sizing. The selection and sizing of a circulator shall be based on all of the following:

(1) Loop or system head pressure
(2) Capacity, gallons per minute (L/s)
(3) Maximum velocity, feet per second (m/s)
(4) Maximum temperature, °F (°C)
(5) Maximum working pressure, pounds per square inch (kPa)
(6) Fluid type

205.0 Circulators (Circulating Pump). A device that circulates liquids or gases within a closed circuit for an intended purpose.

SUBSTANTIATION:
Circulators, when properly sized, overcome the friction loss of the piping to provide the necessary volume of fluid flow required by the circuits they serve. The circulator is the heart of any hydronic heating system as it moves the water or other fluid through pipes from the heat source to the heat emitters and back again. Circulators move liquids around a closed-loop circuit by creating low pressure on the inlet side of the circulator. Circulators must be properly sized to accomplish this efficiently. The head pressure required to overcome the friction loss of the network of piping the circulator serves may be a single loop, zone or the entire system. The maximum desired velocity of the system fluid as it moves through the system must meet system design specifications. The designer must also take into consideration the maximum temperature and working pressure the circulator will be exposed to during system operation. Lastly, the type of fluid used as the heating medium must be taken into consideration as various mix ratios all have different densities and resulting friction loss.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Greg Towsley, Grundfos

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
1208.0 Circulators.

1208.1 General. Circulators shall be listed for their intended use based on the heat transfer medium. Circulators shall be installed to allow for service and maintenance. The manufacturer’s installation instructions shall be followed for correct orientation and installation.

1208.2 Mounting. The circulator shall be installed in such a way that strain from the piping is not transferred to the circulator housing. The circulator shall be permitted to be directly connected to the piping, provided the piping is supported on each side of the circulator. Where the installation of a circulator will cause strain on the piping, the circulator shall be installed on a mounting bracket or base plate supported in a manner that will eliminate strain on the piping. Where means for controlling vibration of a circulator is required, an approved means for support and restraint shall be provided.

1208.3 Sizing. The selection and sizing of a circulator 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 velocity, feet per second (m/s)
4. Maximum and minimum temperature, °F (°C)
5. Maximum working pressure, pounds per square inch (kPa)
6. Fluid type

205.0 Circulators (Circulating Pump). A device that circulates liquids or gases within a closed circuit for an intended purpose.

SUBSTANTIATION:
Circulators can be installed within the piping, but if the pump becomes too large for the piping it is installed in, it must be supported to not cause any torsional stress on the pump housing that can be translated to the motor or other parts. The revised installation requirements “better” the code text. Pump manufacturers select pumps based on the feet of head. Minimum velocity and temperature is important as well. Furthermore, circulators cannot pump gases. Lastly, the modification will correlate with modifications made by the USEHC Technical Committee in regards to circulators.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:

• The rationale does not identify a safety issue with respect to sizing pumps. Why do we need this section?
• Section 1208.0 talks about “circulators” which is a term used for small pumps in small hydronic loops such as radiant slabs, again the bias of the authors. They should be called “pumps” which is a known term. Therefore, a definition is not needed.
• Section 1208.3 is unnecessary, and velocity is definitely not a factor in pump selection
• This section does not actually require anything with the exception of the part about the pump putting strain on the piping but this applies to all equipment (e.g. air separators), not just pumps, and is also addressed in Section 1210.

PUBLIC COMMENT 2:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) Section 1208.0 talks about “circulators” which is a term used for small pumps in small hydronic loops such as radiant slabs, again the bias of the authors. They should be called “pumps” which is a known term. Therefore, a definition is not needed.
(2) Section 1208.3 is unnecessary, and velocity is definitely not a factor in pump selection.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1. Furthermore, there was no technical justification provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 20   NEGATIVE: 1   NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• The rationale does not identify a safety issue with respect to sizing pumps. Why do we need this section?
• Section 1208.0 talks about “circulators” which is a term used for small pumps in small hydronic loops such as radiant slabs, again the bias of the authors. They should be called “pumps” which is a known term. Therefore, a definition is not needed.
• Section 1208.3 is unnecessary, and velocity is definitely not a factor in pump selection
• This section does not actually require anything with the exception of the part about the pump putting strain on the piping but this applies to all equipment (e.g. air separators), not just pumps, and is also addressed in Section 1210.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 9)

RECOMMENDATION:
Add new text as follows:

1209.0 Expansion Tanks.
1209.1 Where Required. An expansion tank shall be installed in every hydronic system to control thermal expansion. Secondary hot water systems, that are isolated from the primary system by a heat exchanger shall install a separate expansion tank and pressure relief valve. Expansion tanks shall be of the closed or open type. Expansion tanks used in hydronic systems shall comply with the requirements of ASME Boiler and Pressure Vessel Code Section VIII where the diameter of the tank is greater than 24 inches (610 mm) or where the operating temperature exceeds 250°F (121°C). Tanks shall be rated for the pressure of the system. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions.

1209.2 Systems with Closed Expansion Tanks. A closed expansion tank shall be sized based on the capacity of the system. The minimum size of the tank shall be determined in accordance with Section 1005.4 and shall be equipped with an air-tight tank or other air cushion that is consistent with the volume and capacity of the system. Tanks without membranes shall be equipped with a drain valve and a manual air vent. Tanks shall be located in accordance with the manufacturer’s instructions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

1209.3 Systems with Open Expansion Tanks. An open expansion tank shall be located not less than 36 inches (914 mm) above the highest point in the system and shall be sized based on the capacity of the system. An overflow with a diameter of not less than one-half the size of the water supply or not less than 1 inch (25 mm) in diameter shall be installed at the top of the tank. The overflow shall discharge through an air gap into the drainage system. Isolation valves shall not be installed in the piping between the heat-distribution system and the expansion tank. Tanks shall be located in accordance with the manufacturer’s instructions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

SUBSTANTIATION:
All hydronic systems must account for the thermal expansion of the heating fluid. Hydronic systems are found in two categories, open and closed systems. Expansion tanks provide a reservoir for the volumetric change to occur. Open systems use a “feed and expansion” tank (cistern). As the name suggests, the tank is used to feed the supply and to accommodate any water expansion that is generated by the heating process. The “feed and expansion” tank is placed at the highest point in the system. An open-vented system typically uses a small-bore two pipe network, where one pipe is used to feed the system and the other allows the cooled water to return to the heat source (boiler). When the fluid in such a closed system is heated, it will expand and, because it is a closed system, quickly cause hydrostatic pressure that can be relieved only by system failure or the opening of the safety relief valve. Relief valves are intended to open only in the event of an emergency, the continuous opening of a relief valve to accommodate expansion is not acceptable. Expansion tanks are used to absorb the additional system water volume caused by expansion, thus avoiding relief valve opening and preventing wide variations in system pressure. Expansion tanks are either sealed vessels or open tank reservoirs. Open tank reservoirs are, of course, not pressurized except for the static elevation head they impose on the heat source. Closed expansion tanks, however, are pressurized vessels. Because they are subjected to the same pressures as the system, closed expansion tanks must have a pressure rating greater than or equal to the maximum system operating pressure. All sections correlate with Chapter 10.

COMMITTEE ACTION: Accept as Submitted
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Tim Ross, Ross Distributing, Inc.

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

1209.1 Where Required. An expansion tank shall be installed in every hydronic system to control thermal expansion. Secondary hot water systems, that are isolated from the primary system by a heat exchanger shall install a separate expansion tank and pressure relief valve. Expansion tanks shall be of the closed or open type. Expansion tanks used in hydronic systems shall comply with the requirements of ASME Boiler and Pressure Vessel Code Section VIII where the system is designed to operate at more than 30 pounds-force per square inch (psi) (207 kPa) diameter of the tank is greater than 24 inches (610 mm) or where the operating temperature exceeds 250°F (121°C). Tanks shall be rated for the pressure of the system. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions.

SUBSTANTIATION:
Section 1209.1 should be modified as expansion tanks are required to comply with ASME BPVC Section VIII when the pressure is expected to exceed 30 psi. This is consistent with ASME BPVC Section IV and industry standards. Furthermore, it will be consistent with the requirements in Section 1004.3.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

EXPLANATION OF AFFIRMATIVE:
CABOT: While the comment address a section not included as part of the proposal, it is raised in another proposal and did receive a public review.

PUBLIC COMMENT 2:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

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 or above 30 pounds-force per square inch (psi) (207 kPa) shall be constructed in accordance with nationally recognized standards and the Authority Having Jurisdiction. Provisions shall be made for draining the tank without emptying the system, except for pressurized systems.

1209.2 Systems with Closed Expansion Tanks. A closed expansion tank shall be sized based on the capacity of the system. The minimum size of the tank shall be determined in accordance with Section 1004.3 1004.4 and shall be equipped with an airtight tank or other air cushion that is consistent with the volume and capacity of the system. Tanks without membranes shall be equipped with a drain valve and a manual air vent. Tanks shall be located in accordance with the manufacturer’s instruc-
tions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

SUBSTANTIATION:
All expansion tanks, bladder type, diaphragm type, and open steel tank type require a drain valve between the isolation valve and the tank. This is to facilitate required annual testing and recharging of the tank's diaphragm or bladder pressure. The manufacturers state in their installation literature that in order to correctly check the diaphragm/bladder pressure that the fluid side must be bled to a pressure of zero psi gauge. Without this convenient drain, it becomes necessary to release the pressure from another part of the physical plant, thereby causing air binding and other issues. In the case of an open steel (bladder-less and diaphragm-less) tank, it is there to facilitate the complete draining and atmospheric pressure balancing of the tank prior to recharging with the system fluid.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 3:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) Section 1209.0 is redundant with Section 1004.0, although expansion tanks are required in any closed system, I agree that expansion tanks should be addressed in Chapter 12 and not in Chapter 10.
(2) Section 1209.1 requires two expansion tanks for primary/secondary systems which is completely unnecessary and not, at all, a standard practice. One tank can serve both systems. Furthermore, it requires only large tanks with high temperatures to be ASME listed which conflicts with Section 1004.3. Section 1004.3 requires a listing for any tank above 30 psi.
(3) In Section 1209.2, is “heating-system-centric” rather than addressing all closed hydronic systems.
(4) In Section 1209.3, it appears to require expansion tanks on open systems like cooling tower systems. Furthermore, it says that valves cannot be located between the tank and system then later says a valve is required.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 1 and Public Comment 2. Furthermore, there was no technical justification provided to warrant the change.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20  NEGATIVE: 1  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: Substantial language cleanup is required and also needs to be merged with Chapter 10 expansion tank requirements. Expansion tanks are required on all closed systems, not just HW systems.
1210.0 Materials.
1210.1 Pipe, Tube, 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 transfer medium. Pipe fittings and valves shall be approved for the installation with the piping, materials to be installed and shall conform to the applicable standards referenced in Table 1210.1. Exterior piping shall be protected against freezing, UV radiation, corrosion and degradation. Embedded pipe or tubing shall comply with Section 1221.2.

Part I – Steam and Water Piping.
1201.0 General.
1201.1 Applicability. Steam and water piping systems that are part of a heating or cooling system shall comply with the following requirements.
1201.2 High Pressure Systems. Portions of piping systems in which the pressure exceeds 160 pounds-force per square inch gauge (psig) (1103 kPa) or the temperature exceeds 250°F (121°C) shall comply with nationally recognized standards and the requirements of Section 1201.3.
1201.3 Low Pressure Systems. Portions of piping systems in which the pressure does not exceed 160 psig (1103 kPa) and the temperature does not exceed 250°F (121°C) shall comply with the following requirements.
1201.3.8 Installation. Piping materials used, except valves and similar devices, shall be of a like material, except as otherwise acceptable to the Authority Having Jurisdiction.
1201.3.8.1 Wall Thickness. Piping shall be not less than standard weight brass or copper, Class 150 cast-iron, standard-weight wrought iron, ASTM Schedule 40 steel, or asbestos cement of approved pressure rating.
1201.3.8.6 (D) Exposed Piping. Exposed piping subject to excessive corrosion, erosion, or mechanical damage shall be protected.
1201.3.8.6 (H) Freezing. Where required, piping outside of a building or in an exterior wall shall be protected from freezing.
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 Table 316.2. Systems with valves, circulators, and expansion tanks shall be provided with additional support in accordance with this code and manufacturer’s installation instructions.
1201.3.7 Hangers and Supports. Hot water and steam piping shall be supported, anchored, and provided with swing joints, expansion loops or joints, or other means to avoid excessive strain on piping, equipment, or the building structure. Piping and tubing hangers and supports shall comply with requirements listed in Section 316.0.
1201.3.8.3 Providing for Expansion, Contraction, and Settling. Piping shall be installed so that piping, connections, and equipment shall not be subjected to excessive strains or stresses, and provisions shall be made for expansion, contraction, shrinkage, and structural settlement.
1201.3.12 Flashing Material. Flashing material shall be lead, copper, galvanized iron, or other approved materials.
1201.3.14 Hangers and Anchors. Hangers and anchors shall be approved for the use intended.
### MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARDS</th>
<th>INSTALLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PIPING/TUBING</td>
<td>FITTINGS</td>
</tr>
<tr>
<td>Asbestos Cement*</td>
<td>ASTM C-296</td>
<td>—</td>
</tr>
<tr>
<td><strong>METALLIC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bronze</td>
<td>—</td>
<td>ASME B16.24</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><strong>PLASTIC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrylonitrile Butadiene Styrene (ABS)</td>
<td>ASTM D1527</td>
<td>—</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389</td>
<td>—</td>
</tr>
<tr>
<td>Raised Temperature Polyethylene (PE-RT)</td>
<td>ASTM F2623, ASTM F2769</td>
<td>ASTM F1807, ASTM F2159, ASTM F2735, ASTM F2769</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>
</tbody>
</table>

**Notes:**

1. Ductile and gray iron.
2. Only type K, L, or M tubing allowed to be installed.
3. Used only for low-pressure hydronic system with water without additives.

**1201.4 PEX Tubing.** Hydronic piping systems where the continuous pressure/temperature does not exceed the values in Table 1201.4 shall be permitted to be constructed of cross-linked polyethylene (PEX) tubing.
1201.4.1.1 Fittings. Fittings shall be manufactured and tested in accordance with the nationally recognized standards.

1201.5 PEX-AL-PEX. Hydronic piping systems where the continuous pressure/temperature does not exceed the values in Table 1201.5 shall be permitted to be constructed of cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) piping.

<table>
<thead>
<tr>
<th>TEMPERATURE (°F)</th>
<th>PRESSURE (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>160</td>
</tr>
<tr>
<td>180</td>
<td>100</td>
</tr>
<tr>
<td>200</td>
<td>80</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8, 1 pound-force per square inch = 6.8947 kPa

1201.6 Polypropylene Pipe. Hydronic piping systems where the continuous pressure/temperature does not exceed the values in Table 1201.6 shall be permitted to be constructed of polypropylene (PP) piping.

<table>
<thead>
<tr>
<th>TEMPERATURE (°F)</th>
<th>PRESSURE (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>200</td>
</tr>
<tr>
<td>180</td>
<td>125</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8, 1 pound-force per square inch = 6.8947 kPa

1201.7 PE-RT Tubing. Hydronic piping systems where the continuous pressure/temperature does not exceed the values in Table 1201.7(1) shall be permitted to be constructed of raised temperature polyethylene (PE-RT) tubing.

<table>
<thead>
<tr>
<th>TEMPERATURE (°F)</th>
<th>PRESSURE (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>160</td>
</tr>
<tr>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>190</td>
<td>80</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32)/1.8, 1 pound-force per square inch = 6.8947 kPa
TABLE 1201.7(2)
PE-RT TUBING PRESSURE/TEMPERATURE (ASTM F2769)

<table>
<thead>
<tr>
<th>TEMPERATURE (°F)</th>
<th>PRESSURE (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>160</td>
</tr>
<tr>
<td>140</td>
<td>100</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32) / 1.8, 1 pound-force per square inch = 6.8947 kPa

1201.8 PE-AL-PE. Hydronic piping systems where the continuous pressure/temperature does not exceed the values in Table 1201.8 shall be permitted to be constructed of Polyethylene/Aluminum/Polyethylene (PE-AL-PE) piping.

TABLE 1201.8
PE-AL-PE PRESSURE-TEMPERATURE

<table>
<thead>
<tr>
<th>TEMPERATURE (°F)</th>
<th>PRESSURE (psi)</th>
</tr>
</thead>
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<tr>
<td>73</td>
<td>200</td>
</tr>
<tr>
<td>140</td>
<td>150</td>
</tr>
<tr>
<td>180</td>
<td>100</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32) / 1.8, 1 pound-force per square inch = 6.8947 kPa

Those portions of the hot water piping systems in which the continuous pressure/temperature relationship does not exceed Table 1201.7(2) shall be permitted to be constructed of raised temperature polyethylene (PE-RT) tubing in accordance with ASTM F2769.

1201.3.1 Standards. Piping, tubing, and fittings materials for hydronic systems shall comply with the applicable standards referenced in Table 1201.3.1.

1201.3.2 Materials and Construction. Pipe shall be brass, copper, cast-iron, galvanized or black wrought iron, galvanized or black steel, or other approved materials.

1201.3.2.1 Tubing. Tubing shall be copper water tube.

1201.3.2.16 Standards. Piping, tubing, valves, joints, fittings, devices, and materials shall be free of defects and comply with nationally recognized standards.

1201.5.1.1 Fittings. Fittings shall be manufactured and tested in accordance with the nationally recognized standards.

1201.6.1.1 Fittings. Fittings shall be manufactured and tested in accordance with the ASTM F2769.

1201.7.1.1 Fittings. Fittings shall be manufactured and tested in accordance with the Section 1201.7.2.

1201.8.1.1 Fittings. Fittings shall be manufactured and tested in accordance with the nationally recognized standards.

1201.3.2.7 Asbestos–Cement. Fittings for asbestos-cement shall be made of cast-iron.

1201.3.4.6 Asbestos-Cement Piping. Joints in asbestos-cement piping shall be mechanical type and approved for the service temperature intended.

1201.3.8.5 (E) Asbestos-Cement Piping. Asbestos-cement piping shall not be installed within a building.

1201.3.7.1 In Ground. Piping and tubing in the ground shall be laid on a firm bed for its entire length except where otherwise approved by the Authority Having Jurisdiction. Asbestos-cement piping shall be provided with approved thrust blocking.

1201.3.8.1(A) Condensate Return Lines. Tubing shall be not less than Type K, for condensate return lines; Type L, for steam condenser cooling water lines, underground water lines, and aboveground water lines; Type M, for aboveground water lines not embedded in concrete or masonry.

1201.3.8.5 Underground Piping. Piping passing through or under cinders or other corrosive fill materials shall be protected from corrosion.
Exception: Where a soil analysis by an approved testing laboratory shows the soil to be free of materials that are capable of corroding the pipe to be installed, the requirements for protective coatings shall be permitted to be waived.

1201.3.8.5 (C) Openings into Buildings. Voids around piping passing through concrete or masonry floors or walls shall be sealed at the opening into the building. Sleeves shall be provided at such openings.

1201.3.8.6 Aboveground Piping. Sleeves shall be provided to protect piping through concrete and masonry walls.

1201.3.8.6 (F) Roof and Wall Openings. Joints at the roof around pipes or appurtenances shall be made watertight by the use of approved flashings or flashing material. Exterior wall openings shall be made watertight.

1201.3.2.17 Marking. Materials and devices shall be identified. In addition to the incised marking required in the standards, hard-drawn copper tubing shall be marked in accordance with the applicable standard found in Chapter 17. Color coding shall be as follows:

1. Type L—Blue
2. Type K—Green
3. Type M—Red
4. Type ACR—Blue
5. Type DWV—Yellow

SUBSTANTIATION:
Section 1201.2 and Section 1201.3 have been deleted as the these sections covers only portions of piping systems intended to supply hot water or steam or low pressure systems that operate at pressures less than or equal to 15 psi. Hydronic systems that fall under our applicability have a wide range of temperatures and pressures and in order to not conflict with our applicability these sections have been deleted. In addition, the definition for high pressure system and low pressure system is a definition and not a requirement. High pressure boiler has the same definition as high pressure system in Chapter 2.

The last 2 columns of Table 1210.1 have been deleted in order to clarify that not all materials listed in Table 1210.1 are approved for installation underground and aboveground. This table is incorrect and approval of materials should not be based on whether you can install such materials aboveground or underground. For example, the table indicates that copper may be installed underground and aboveground. Only type K and L is suitable for underground installation or embedded in concrete. In addition, the table indicates that ductile iron pipe may be installed underground and aboveground. The standard for flanged ductile iron pipe is AWWA C115 and the standard states that this material is not recommended or suitable to be installed underground. The standard for hub and spigot ductile iron is AWWA C 151 and the standard states that this material is not approved or suitable for aboveground installation.

Asbestos-cement piping should be removed from the UMC. Asbestos-cement piping is no longer manufactured in North America. Furthermore, the potential health issues associated with this material makes it unsafe for most water supply and drainage applications. If for some reason an individual wanted to use this piping material they could always do so in accordance with Section 301.2 (Alternate Materials and Methods of Construction Equivalency).

Asbestos-cement piping should be removed from the UMC. Asbestos-cement piping is no longer manufactured in North America. Furthermore, the potential health issues associated with this material makes it unsafe for most water supply and drainage applications. If for some reason an individual wanted to use this piping material they could always do so in accordance with Section 301.2 (Alternate Materials and Methods of Construction Equivalency).

Materials must be rated for the operating temperature and pressure of the hydronic system. Materials must be suitable for the type of fluid in the hydronic system. Heat transfer fluids, system operating and standby pressures and temperatures all vary widely depending on the application. All portions of a hydronic system must be compatible with the working fluid, rated for the operating temperatures and pressures of the system. The lowest rating of any of the components establishes the operating limitations of the system. Note that the pressure and temperature may vary significantly within a system, and different materials may be needed at different locations in the system. For example, in a high-rise building, the static pressure of hydronic piping is greater in the lower floors than in the upper floors, which means that the piping and components at the lower elevations must be rated for the higher pressures.

Expansion and contraction for piping and tubing are addressed to prevent failure of pipe and supports; joint damage and leakage; and the transmission of detrimental forces and stresses to connected equipment and building components.

As with all piping systems, support of the system is as important as any other part of the overall design. Proper supports are necessary to maintain piping alignment and slope, to support the weight of the piping and its contents, to
control movement and to resist hydrodynamic loads, such as thrust. Manufacturer’s recommendations and installation instructions may dictate hanger spacing because specialized support methods are needed to address the unique characteristics of the material. Piping supports must be installed to prevent damage to the piping caused by thermal expansion and must not react with or be detrimental to the pipe they support.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) Section 1210.0 eliminates many detailed requirements that were required prior to the modification of Chapter 12. I agree that most of the provisions were vague and unenforceable, but the Committee should review each one before eliminating just to be sure. For example, the standard weight (e.g. schedule 40) steel is no longer required for heating systems so, for instance, schedule 10 may be used; was that the intention?
(2) Section 1210.1 requires protection from UV radiation for all piping, apparently even piping that does not need it like copper and steel.
(3) Table 1210.1 eliminates brass and bronze fittings, basically eliminating copper piping systems.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of piping, tubing, and fitting materials used in hydronic systems. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22
VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• Section 1213.0 is “heating-system-centric” rather than addressing all hydronic systems. At best it is incomplete.
• Energy standards already address space temperature controls and simultaneous heating and cooling restrictions. This is not an energy standard.
• Chapter 9 and Chapter 10 address equipment safety controls already.
• Furthermore, the language is vague and says nothing substantive. It basically says to “install controls to control things.” There is no meat just a lot of words that add bulk to the code.
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 having a radius of not less than six times the outside diameter of the tubing. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1201.3.5 Changes in Direction. Changes in direction shall be made by the approved use of fittings, except that changes in direction in copper tubing shall be permitted to be made with bends having a radius not less than six diameters of the tubing, provided that such bends are made by the use of forming equipment that does not deform or reduce appreciably the cross-sectional area of the tubing.

1201.3.2.3 Fittings. Plain screwed fittings shall be brass, bronze, cast iron, galvanized or black malleable iron, or galvanized or black steel.

1201.3.3 Fabrication of Joints. Joints shall be made by the use of fittings except as otherwise permitted in this chapter.

1201.3.4.8 Piping to Tubing. Joints connecting piping to tubing shall be made with adapter fittings connected as required in Section 1201.3.1.1 through Section 1201.3.4.7.

1201.8.2 Changes in Direction. Changes in direction shall be made by the approved use of fittings or with pipe bends having a radius of not less than six times the outside diameter of the piping. No forming equipment or heating is required.

1201.3.2.13 Gaskets. Flange gaskets shall be metal, asbestos, or other approved materials.

1201.5.3 Changes in Direction. Changes in direction shall be made by fittings or with pipe bends having a radius of not less than five times the outside diameter of the piping. No forming equipment or heating is required.

1201.4.3 Changes in Direction. Changes in direction shall be made by the use of fittings or with pipe bends having a radius of not less than six times the outside diameter of the tubing. No forming equipment or heating is required.

1201.7.3 Changes in Direction. Changes in direction shall be made by the approved use of fittings or with pipe bends having a radius of not less than six times the outside diameter of tubing. No forming equipment or heating is required.

1201.3.6 Changes in Pipe Sizes. Where different sizes of pipe or pipe and fittings are to be connected, the approved size increasers or reducer fittings shall be used between the two sizes. Where the branch is not less than two sizes smaller than the main, weldolets or threadolets shall be permitted to be used in lieu of welding tees. Bushings shall not be used. Eccentric reducing fittings shall be used wherever necessary to provide free drainage of lines.

1201.3.4 Connections.

1201.3.4.1 Brass and Copper Piping. Joints in brass and copper piping shall be threaded, brazed, welded, flanged, or mechanical type.

1201.3.2.8 Pipe Joint Compound. Pipe joint compound shall be noncorrosive and insoluble in the material being carried in the pipe.

1211.2 Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe. Joints between chlorinated poly (vinyl chloride) (CPVC) pipe or fittings shall be installed in accordance with one of the following methods:

(1) Removable and non-removable push fit fittings with an elastomeric O-ring that employ quick assembly push fit connectors listed or labeled 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, \( \frac{1}{2} \) of an inch (15 mm) through 2 inches (50 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 Copper Pipe and Tubing. Joints between copper pipe, tubing, or fittings shall be installed in accordance with one of the following methods:

1. Brazed joints between copper 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 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 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 \( \frac{1}{4} \) 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 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. 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 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 tubing or pipe that employ quick assembly push fit connectors shall be in accordance with ASSE 1061. Push fit fittings for copper 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 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 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.

4201.3.2.4 Copper Tubing. Fittings for copper tubing shall be wrought copper, wrought bronze, or cast bronze.

1201.3.2.5 Mechanically Formed Tee Fittings. Mechanically extracted collars shall be formed in a continuous operation consisting of drilling a pilot hole and drawing out the tube surface to form a collar having a height not less than three times the thickness of the branch tube wall.
The branch tube shall be notched to comply with the inner curve of the run tube and have two dimple/depth stops to ensure that penetration of the branch tube into the collar is of an approved depth for brazing and that the branch tube does not obstruct the flow in the main line tube. Dimple or depth stops shall be in line with the run of the tube. The second dimple shall be \( \frac{1}{4} \) of an inch (6.4 mm) above the first and shall serve as a visual point of inspection. Joints shall be brazed in accordance with Section 212.0. Soft soldered joints shall not be allowed.

1201.3.3.2 Solder Joints. Surfaces to be joined by soldering shall be cleaned bright by manual or mechanical means. The joints shall be fluxed using a listed soldering flux. (See standards for soldering fluxes in Chapter 17). Tubing shall be reamed out to the full size of bore.

1201.3.3.4 Flanged Joints. Flanged joints shall be tightened evenly and provided with approved nuts, bolts, and gaskets.

1201.3.3.5 Copper Tubing. Mechanical joints shall comply with nationally recognized standards.

1201.3.4.7 Copper Tubing. Joints in copper tubing shall be soldered, brazed, grooved, pressed, flared, or compression except that joints under a building and in or under a concrete slab resting on the ground shall be brazed, or equal, and fittings shall be of wrought copper. Mechanically formed tee fittings are also acceptable where brazed and installed in accordance with Section 1201.3.2.5. Solder joints shall be made with solders meeting the standard for solder metal found in Chapter 17. Where steam pressures exceed 15 psig (103 kPa) or water pressures exceed 30 psig (207 kPa), then 50 percent tin-50 percent lead solder shall not be used. Solders and fluxes with a lead content which exceeds two-tenths of 1 percent shall be prohibited in piping systems conveying potable water.

1201.3.2.10 Fluxes. Fluxes for solder, sweat, and brazed joints shall be a noncorrosive type and intended for the use.

1211.4 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.

1201.4.1 Materials and Construction. PEX tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1201.4.1.3 Hangers, Sleeves, and Anchors. Hangers, sleeves, and anchors shall be approved for the use intended as recommended by the manufacturer’s instructions.

1201.4.1.4 Marking. Materials and devices shall be identified.

1201.4.2 Fabrication of Joints. Joining methods shall comply with the performance requirements of ASTM F877. Joints shall be made by one or more of the following methods:

1. Insert fittings of metal with crimp rings of copper shall be permitted to be used.
2. Metallic fittings utilizing compression seals shall be permitted to be used.
3. Cold expansion fittings utilizing a PEX reinforcing ring or metal compression sleeve shall be permitted to be used.
4. Connections to other piping materials shall be made of approved types of special transition fittings.

1211.5 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 listed or labeled 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.

1201.5.1 Materials and Construction. PEX-AL-PEX piping and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1201.5.1.3 Hangers, Sleeves, and Anchors. Hangers, sleeves, and anchors shall be approved for the use intended as recommended by the manufacturer’s instructions.
1201.5.1.4 Markings. Materials and devices shall be identified.

1201.5.2 Fabrication of Joints. Joining methods shall comply with the performance requirements set forth in ASTM F1281. Joints shall be made by one or more of the following methods:

1. Insert fittings of metal with crimp rings of copper shall be permitted to be used.
2. Metallic fittings utilizing a split ring and compression nut shall be permitted to be used.
3. Connections to other piping materials shall be made of approved types of special transition fittings.

1211.6 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.

1211.7 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe, tubing, or fittings shall be installed in accordance with ASTM D2657 and one of the following heat fusion methods:

1. Butt-fusion joints 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 made by embedding the resistance wire in the fitting and supplying with a heat source. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.
3. Socket-fusion joints 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 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.

1211.8 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 that the edge of the crimp ring is 1/8 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.
1201.8.1 Materials and Construction. PE-AL PE piping and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1201.8.1.2 Hangers, Sleeves, and Anchors. Hangers, sleeves, and anchors shall be approved for the use intended as recommended by the manufacturer’s instructions.

1201.8.1.3 Marking. Materials and devices shall be identified.

1201.8.1.4 Fabrication of Joints. Joining methods shall comply with ASTM F1282 or ASTM F1974. Joints shall be made by one or more of the following methods:

1. Insert fittings of metal or plastic with crimp rings of copper shall be permitted to be used.
2. Metallic fittings utilizing compression seals shall be permitted to be used.
3. Connections to other piping materials shall be made of approved types of special transition fittings.

1201.9 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.

1201.7.1 Materials and Construction. PE-RT tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1201.7.1.2 Hangers, Sleeves and Anchors. Hangers, sleeves, and anchors shall be approved for the use intended as recommended by the manufacturer’s instructions.

1201.7.1.3 Marking. Materials and devices shall be identified.

1201.7.2 Fabrication of Joints. Fittings shall be manufactured and tested in accordance with the application for which they are intended. Joints shall be made by one or more of the following methods:

1. Insert fittings of metal or plastic with crimp rings of copper shall be permitted to be used.
2. Metallic fittings utilizing compression seals shall be permitted to be used.
3. Connections to other piping materials shall be made of approved types of special transition fittings.

1211.10 Polypropylene (PP) Pipe. Joints between cross-linked 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 brass or stainless steel inserts molded in the fitting.

1201.6.1 Materials and Construction. Polypropylene pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1201.6.1.2 Hangers, Sleeves and Anchors. Hangers, sleeves, and anchors shall be approved for the use intended as recommended by the manufacturer’s instructions.

1201.6.1.3 Marking. Materials and devices shall be identified. Polypropylene (PP) pipe and fittings shall be marked in accordance with ASTM F2389.

1201.6.1.4 Heat-Fusion Joints. Heat fusion for polypropylene (PP) pipe and fitting joints 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.

1201.6.1.5 Mechanical and Compression Sleeve Joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions.

1211.11 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 be listed or labeled in accordance 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.

1211.12 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.

1201.3.3.3 Welded Joints. Welding shall be performed in accordance with nationally recognized standards by certified welders.

1201.3.3.1 Screwed Joints. Threads on iron pipe size (IPS pipe) shall be standard taper pipe threads. Burrs shall be removed. Pipe ends shall be reamed or filed out to the full size of bore, and chips shall be removed.

1201.3.4.2 Cast-Iron Piping. Joints in cast-iron pipe shall be threaded, flanged, or mechanical type.

1201.3.4.3 Galvanized Wrought-Iron and Galvanized Steel Piping. Joints in galvanized wrought-iron and galvanized steel piping shall be threaded, flanged, or mechanical type.

1201.3.4.4 Black Wrought-Iron Piping. Joints in black wrought-iron piping shall be threaded, brazed, welded, flanged, or mechanical type, except that joints built into or embedded in concrete or masonry shall be welded.

1201.3.4.5 Black Steel Piping. Joints in black steel piping shall be threaded, brazed, welded, flanged, or mechanical type.

1211.13 Joints Between Various Materials. Joints between various materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 1211.13.1 through Section 1211.13.2.

1211.13.1 Copper Pipe or Tubing to Threaded Pipe Joints. Joints from copper pipe or tubing to threaded pipe shall be made by the use of brass adapter, brass nipple [minimum 6 inches (152 mm)], dielectric fitting, or dielectric union in accordance with ASSE 1079. The joint between the copper 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.

1211.13.2 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.

1201.6.1.6 Transition Fittings. Connections to other piping materials shall be made with approved types of transition fittings.

SUBSTANTIATION:
Approval of joints and connections must consider the compatibility of the joint or connection with the working fluid of the system and the pipe materials being joined. Joints and connections must be able to withstand the maximum operating conditions of the system. The same format for joining methods and materials is in the UPC, USEC, and USPSHTC. Redundant language for each material is not necessary. No need to restate marking requirements, hanger and sleeve requirements over and over.
COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Tim Ross, Ross Distributing, Inc.

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

1211.13.1 Copper Pipe or Tubing to Threaded Steel Pipe Joints. Joints from between copper or copper alloy pipe or tubing to threaded steel pipe shall be made by the use of with a brass adapter, brass nipple (minimum 6 inches (152 mm), dielectric fittings, or dielectric union in accordance with ASSE 1079. The joints 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.

SUBSTANTIATION:
There are many factors affecting corrosion in a system including the amount of oxygen (fuels corrosion) the chemical makeup of the solution being used, galvanic corrosion resulting from the coupling of dissimilar metals, temperature, and pressure, and flow rates. When copper or copper-alloy tubing is joined with steel pipe, protection against galvanic corrosion is required. Galvanic corrosion (electrolysis) requires the presence of two different metals, a conductive (metallic) path between them, and an ionic path (water or moisture connecting the two metals).

Galvanic corrosion does not occur when metals are dry. Systems handling noncondensing air, nitrogen, or other gases can have dissimilar metals joined together without concern for galvanic corrosion. Many drinking water and process water transporting pipelines have corrosion problems in open and closed systems or cooling and heating processes as a consequence of the use of several metals. Galvanic corrosion of dissimilar metals happens at varying degrees based on a couple of variables. Differences in the molecular makeup of the metals and the level of moisture and humidity both play large roles. The two separate metals will be either more anodic or cathodic than each other. For example, copper upon entering a galvanized system, will plate out on the zinc surface. Copper, being the more noble or inactive metal, and then becomes the cathode. The zinc (or steel) becomes the anode and goes into solution. This type of problem usually is accompanied by severe tuberculation inside the pipe. Greater differences between the metals will cause accelerated and more dramatic corrosion. For instance, gold and silver are very close together on the anodic index, and therefore ionic migration resulting in corrosion between them would be comparatively minor. In contrast, copper and iron are more dissimilar and therefore corrosion in the same environment would be greater.

Prevention
The most common process for preventing dissimilar metals corrosion is to prevent the metals from touching, otherwise known as “insulating” with a dielectric fitting or dielectric union. Dielectric fittings provide an electrical barrier to prevent the passage of electric current either between dissimilar metals or between the piping and the electrolyte.

Conclusions
Although different metals are used in a heating or air-conditioning piping system it should be noted that using dielectric isolators is not a substitute for proper water chemistry control, and that proper water chemistry control can eliminate the need for dielectric fittings, and also ensures a long service life for the piping system. Water chemistry determines corrosion rate. Corrosion rate determines system longevity. Therefore, water chemistry determines system longevity.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed modification eliminates other applications such as threaded joints and 6 inch brass nipples which are acceptable methods used for joining dissimilar metals. Furthermore, the modification changes the intent of the section.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  
AFFIRMATIVE: 20  
NEGATIVE: 1  
NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:  
RAMOCIOTTI: The bending radius of 6 times still applies to copper tubing. This change will delete needed clarity and direction for materials to be used.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 315 and UPC Item # 051 (Public Comment 2), Item # 196, and Item # 197 resulted in a conflict within this code. Furthermore, it will correlate with the actions taken by the USEHC to accept as submitted Item # 115 in regards to joints and connections of polyethylene for electrofusion. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

1211.3 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) (remaining text unchanged)

(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. 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 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 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 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.
1211.2 Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe. Joints between chlorinated poly (vinyl chloride) (CPVC) pipe or fittings shall be installed in accordance with one of the following methods:

1. Removable and non-removable push fit fittings with an elastomeric O-ring that employ quick assembly push fit connectors listed or labeled 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 \( \frac{1}{2} \) of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442 \( \frac{1}{2} \) of an inch (15 mm) through \( \frac{3}{8} \) inches (480 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.

1211.5 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 utilizing a crimping ring. Insert fittings utilizing a crimping ring shall be listed or labeled 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.

1211.7 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe, tubing, or fittings shall be installed in accordance with ASTM D2657 and one of the following heat fusion methods:

1. Butt-fusion joints shall be installed in accordance with ASTM F2620 and shall be made by heating the squared ends of two pipes, pipe and fitting, or two fittings by holding ends against a heated element. The heated element shall be removed where the proper melt is obtained and joined ends shall be placed together with applied force.

2. Electro-fusion joints shall be heated internally by a conductor at the interface of the joint made by embedding the resistance wire in the fitting and applying with a heat source. 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. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.

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. (remaining text unchanged)

1211.10 Polypropylene (PP) Pipe. Joints between cross-linked 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 brass copper alloy or stainless steel inserts molded in the fitting.

1211.11 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 be listed or labeled in accordance 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.

(remaining text unchanged)

1211.13.1 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 brass copper alloy adapter, brass 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.

1308.5.2.3 Copper and Brass Copper Alloy. Copper and brass copper alloy pipe shall not be used where the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet (scf) of gas (0.7 mg/100 L). [NFPA 54:5.6.2.3]

Threaded copper, brass copper alloy, or aluminum alloy pipe shall not be used with gases corrosive to such material. [NFPA 54:5.6.2.4]

1308.5.3.2 Copper and Brass Copper Alloy. Copper and brass 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. [NFPA 54:5.6.3.2]

1308.5.10.4 Metallic Pipe Fittings (Including Valves, Strainers, Filters). Metallic pipe fittings shall comply with the following:

(1) (remaining text unchanged)
(2) Fittings used with steel or wrought-iron pipe shall be steel, brass, bronze copper alloy, malleable iron, or castiron.
(3) Fittings used with copper or brass copper alloy pipe shall be copper, brass, or bronze copper alloy.
(4) – (7) (remaining text unchanged)
(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. [NFPA 54:5.6.8.4]

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<td>Joints</td>
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(portions of table not shown remain unchanged)

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
Section 1211.3, Section 1211.10(2), Section 1211.13.1, Section 1308.5.2.3, Section 1308.5.3.2, and Section 1308.5.10.4 are being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 051 in regards to the use of copper alloy. The revisions to Sections 1211.2, 1211.3, 1211.5, 1211.7, 1211.10, 1211.11, and 1211.13.1 of the UMC will correlate with the actions taken by the USEHC TC to “accept as submitted” Item # 043. Section 1211.7 of the UMC is being revised to correlate with the USEHC as it makes reference to ASTM D2657 which is the incorrect standard for polyethylene which is applicable to only polyolefin. The revisions to Section 1211.7(1) and Section 1211.7(3) of the UMC makes reference to ASTM F2620 to correlate with the
USEHC as ASTM F2620 is the appropriate standard for heat fusion joining of polyethylene pipe and fittings. Section 1211.2(2) is being revised by adding reference to ASTM F442 to correlate with the action taken by the UPC TC to “accept as submitted” Item # 196. Furthermore, the pipe sizing requirements in Section 1211.2(2) of the UMC are being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 196. All other modifications were done to correlate with similar sections of the UPC. The revision to Section 1211.7(2) is being revised to correlate with Section 703.5.1.1 in regards to the joining methods of PE pipe using electro-fusion.

The substantiation provided by the UPC for accepting Item # 051 (Public Comment 2) is a follows: “In order to correlate throughout the UPC, the text “brass” or “bronze” needs to be replaced with “copper alloy” within the proposed sections. This change will correlate the UPC with terminology that is used within industry standards.”

The substantiation provided by the UPC for accepting Item # 196 is a follows: “CPVC listed to ASTM F442 is commonly used in both sprinkler and plumbing systems. ASTM F442 is also recognized within Table 604.1 as an approved standard for CPVC pipe.”

The substantiation provided by the UPC for accepting the public comment (Item # 196) as submitted is a follows: “ASTM F442 CPVC pipe is used in fire sprinkler piping, which is sized up to 3” for a one-step solvent cement. ASTM D2846 tubing is only used with a one-step solvent cement up to 2”, so these products need to be addressed separately.”

The substantiation provided by the UPC for accepting the public comment (Item # 197) is a follows:

1. “The provisions are redundant in the fact that Section 309.4 (Installation Practices) already requires the manufacturer’s installation instructions to be followed for a plumbing system installation.”
2. “ASTM F402 indicates that the specific safety information for handling solvent cement should be obtained from the container label or Material Safety Data Sheet that are both available from the manufacturer. Therefore, if such information is available from the manufacturer then there really is not a compelling reason for referencing ASTM F402.”

The substantiation provided by the USEHC for accepting Item # 115 is as follows:

“Polyethylene (PE) is in the same chemical family (polyolefin) and is similar in physical characteristics. It 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. In order to maintain a consistent pressure rating over a range of dimensions, PE is manufactured according to dimension ratios to determine wall thickness. 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. One advantage of using the SDR designation is a consistent pressure rating for all pipe diameters unlike Schedule 40 or 80 pipes. In the schedule dimension ratio, pipe pressure ratings decrease as the pipe dimension increases because the pipe wall thickness does not increase proportionally to the pipe diameter. 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.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC.

PUBLIC COMMENT 2:
SUBMITTER: Michael Cudahy, Plastic Pipe and Fittings Association (PPFA)

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

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 having a radius of not less than six times the outside diameter of the tubing. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.
SUBSTANTIATION:
The text “having a radius of not less than six times the outside diameter of the tubing” should be deleted since the section deals with general requirements, and some pipes may have different requirements. I believe this change was made in the draft USEHC code, as well, for the same reason.

COMMITTEE ACTION: Accept the public comment as amended
Amend comment as follows:

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 in accordance with the manufacturer’s installation instructions. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

COMMITTEE STATEMENT:
Section 1211.1 was modified to provide clarity to the end user that the manufacturer’s installation instructions shall be used for the joining and connections when using pipe bends.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS:  AFFIRMATIVE: 14  NEGATIVE: 7  NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
BERGER, DIAS, MANN, RAMOCIOTTI, RIBBS: The bending radius of six times the diameter still applies to copper tubing. This change will delete needed clarity and direction for materials to be used.

CAMPBELL: This comment should be rejected as the 6X diameter radius of the bend is still referenced in many manufacturers instructions for copper and plastic tubing.

FEEHAN: The bending radius of 6 times the diameter applies to copper tubing and is necessary language.

PUBLIC COMMENT 3:
SUBMITTER: Curtis Dady, Viega, LLC

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

1211.12 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.
SUBSTANTIATION:
Section 1211.12 was revised as the section did not include description for press-connected joints for steel pipe and tube. This modification harmonizes the updated press connection fitting standard (IAPMO PS 117) that now includes materials other than copper. Furthermore, the language proposed is in harmony with Section 1211.3 (4).

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 4:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION: Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) Section 1211.1 requires elbows to have a radius of 6 times the pipe diameter, or is it intended that only pipe bends be made with fittings? This text is poorly worded.
(2) Section 1211.13.1 is limited to threaded pipe. The requirements should apply to any joints used for steel. The last sentence should be deleted since joints are already addressed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected based on the action taken on Public Comment 2 and Public Comment 3. Furthermore, there was no technical justification provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The following should be revised as follows:

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 smooth pipe bends having a radius of not less than six times the outside diameter of the tubing. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

1211.13.1 Copper and Copper Alloy Pipe or Tubing to Threaded Steel Pipe Joints. Joints from copper or copper alloy pipe or tubing to and threaded steel pipe shall be made by the use of with a brass adapter, brass
nipple [minimum 6 4 inches (152 101 mm)], dielectric fitting, or dielectric union in accordance with ASSE 1079. The joint between the copper 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.

Rationale:
- A radius of 6 times the pipe diameter is way more than reasonable. Manufactured elbows have a standard radius of ½ the diameter and even long radius ells have a radius equal to the diameter. The important thing with a pipe bend is that it is not kinked.
- Section 1211.13.1 misses the point: the issue is copper to steel not whether the joint is threaded. The nipple is reduced to 4 inches because that is common practice. The last sentence is deleted because joints are addressed elsewhere and not germane to this section.
315.0 Water Supply Material.

315.1 General Pipe, Tube, and Fittings. Water supply and backflow protection shall be in accordance with the Uniform Plumbing Code. Pipe, tube, and fittings used as supply, drain, hydronics, blowdown, overflow, relief, condensate, or other similar systems shall be of material approved for such use and shall be rated for the operating temperatures and pressures of the system.

315.2 Copper Tube. Copper tube shall have a weight of not less than Type L.

Exception: Type M copper tubing shall be permitted to be used where piping is aboveground in, or on, a building or underground outside of structures.

315.3 Hard-Drawn Copper Tubing. Hard-drawn copper tubing for water supply and distribution, in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

316.0 Joints and Connections.

316.1 Brass Pipe and Joints. Joining methods for brass pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 316.1.1 through Section 316.1.3.

316.1.1 Brazed Joints. Brazed joints between brass pipe and fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). 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. An approved brazing flux shall be applied to the joint surfaces where required by manufacturer’s recommendation. The joint shall be brazed with a brazing filler metal in accordance with AWS A5.8. Brazing filler metal shall be applied at the point where the pipe or tubing enters the socket of the fitting.

316.1.2 Mechanical Joints. Mechanical joints shall be installed in accordance with the manufacturer’s installation instructions. Joints shall include compression, flanged, grooved, press, and threaded.

316.1.3 Threaded Joints. Threads shall comply with ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

316.2 Copper Pipe, Tubing, and Fittings. Joints between copper or copper-alloy pipe, tubing, and fittings shall comply with Section 316.2.1 through Section 316.2.3.

316.2.1 Brazed Joints. Brazed joints between copper pipe or tubing and fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). 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. An approved brazing flux shall be applied to the joint surfaces where required by manufacturer’s recommendation. The joint shall be brazed with a brazing filler metal in accordance with AWS A5.8. Brazing filler metal shall be applied at the point where the pipe or tubing enters the socket of the fitting.

316.2.2 Mechanical Joints. Mechanical joints shall include, but are not limited to, compression, flanged, grooved, pressed, and push fit fittings.

316.2.2.1 Mechanically Formed Tee Fittings. 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 of \( \frac{1}{4} \) 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.
316.2.2 Pressed-Connect Joints. Pressed fittings for copper 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. Pressed fittings for copper 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 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.

316.2.3 Push-Connect Joints. Removable and non-removable push fit fittings for copper pipe or tubing that employ quick assembly push fit connectors shall be in accordance with ASSE 1061. Push fit fittings for copper 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.

316.2.4 Soldered Joints. Solder joints between copper pipe or tubing and fittings shall be made in accordance with the methods of ASTM B828 with the following sequence of joint preparation and operation as follows: measuring and cutting, reaming, cleaning, fluxing, assembly and support, heating, applying the solder, cooling and cleaning. Pipe or tube shall be cut square and reamed to the full inside diameter including the removal of burrs on the outside of the pipe and 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 tube fitting shall be supported to ensure a uniform capillary space around the joint. Heat shall be applied using an air or fuel torch with the flame perpendicular to the pipe or tubing using acetylene or an LP gas. Preheating shall depend on the size of the joint. The flame shall be moved to the fitting cup and alternate between the pipe or tubing and fitting. Solder in accordance with ASTM B32 and 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.

316.2.5 Welded Joints. Welding shall be performed in accordance with nationally recognized standards by certified welders.

(renumber remaining sections)

1201.3.2 Materials and Construction. Pipe shall be brass, copper, copper alloy, cast-iron, galvanized or black wrought iron, galvanized or black steel, or other approved materials.

1201.3.2.1 Tubing. Tubing shall be copper water tube.

1201.3.2.2 Valves. Valves no more than 2 inches (50 mm) in size shall be brass, malleable iron, or steel bodies. Each gate valve shall be a full-way type with working parts of noncorrosive metal.

1201.3.2.3 Fittings. Plain screwed fittings shall be brass, copper, copper alloy, bronze, cast-iron, galvanized or black malleable iron, or galvanized or black steel.

1201.3.2.4 Copper Tubing. Fittings for copper tubing shall be wrought copper, wrought bronze, or cast brass.

1201.3.4.7 Mechanically Formed Tee Fittings. Mechanically extracted collars shall be formed in a continuous operation consisting of drilling a pilot hole and drawing out the tube surface to form a collar having a height not less than three times the thickness of the branch tube wall. The branch tube shall be notched to comply with the inner curve of the run tube and have two dimple/depth stops to ensure that penetration of the branch tube into the collar is of an approved depth for brazing and that the branch tube does not obstruct the flow in the main line tube. Dimple or depth stops shall be in line with the run of the 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.

Joints shall be brazed in accordance with Section 212.0. Soft soldered joints shall not be allowed.

1201.3.4.10 Fluxes. Fluxes for soldering shall be applied to the pipe and fittings and shall be in accordance with ASTM B813, and shall become noncorrosive and non-toxic after soldering. Soldering fluxes shall comply with AWS A5.31 joints shall be a noncorrosive type and intended for the use.

1201.3.4.4 Joints and Connections. Pipe, tubing, and fitting joints and connections shall be installed in accordance with Section 315.1. Joints in brass and copper piping shall be threaded, brazed, soldered, grooved, pressed, flared, compression, welded, flanged, or mechanically formed tees type.
1201.3.4.7 Copper Tubing. Joints in copper tubing shall be soldered, brazed, grooved, pressed, flared, or compression except that joints under a building and in or under a concrete slab resting on the ground shall be brazed, or equal, and fittings shall be of wrought copper. Mechanically formed tee fittings are also acceptable where brazed and installed in accordance with Section 1201.3.2.4. Solder joints shall be made with solders meeting the standard for solder metal found in Chapter 17. Where steam pressures exceed 15 psig (103 kPa) or water pressures exceed 30 psig (207 kPa), then 50 percent tin-50 percent lead solder shall not be used. Solders and fluxes with a lead content which exceeds two-tenths of 1 percent shall be prohibited in piping systems conveying potable water.

1201.3.4.8 Piping to Tubing. Joints connecting piping to tubing shall be made with adapter fittings connected as required in Section 1201.3.4.1 through Section 1201.3.4.7.

1201.3.3 Fabrication of Joints. Joints shall be made by the use of fittings except as otherwise permitted in this chapter.

1201.3.3.1 Screwed Joints. Threads on iron pipe size (IPS pipe) shall be standard taper pipe threads. Burrs shall be removed. Pipe ends shall be reamed or filed out to the full size of bore, and chips shall be removed.

1201.3.3.2 Solder Joints. Surfaces to be joined by soldering shall be cleaned bright by manual or mechanical means. The joints shall be fluxed using a listed soldering flux. (See standards for soldering fluxes in Chapter 17). Tubing shall be reamed out to the full size of bore.

1201.3.3.5 Mechanical Joints. Mechanical joints shall comply with nationally recognized standards.

### TABLE 1201.3.1
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

<table>
<thead>
<tr>
<th>MATERIALS</th>
<th>PIPING/TUBING</th>
<th>FITTINGS</th>
<th>UNDERGROUND</th>
<th>ABOVEGROUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze</td>
<td>—</td>
<td>ASME B16.24</td>
<td>X</td>
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</tr>
</tbody>
</table>

(portions of table not shown remains unchanged)

### TABLE 1701.0
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>AWS A5.31M/A5.31-2012*</td>
<td>Specification for Fluxes for Brazing and Braze Welding</td>
<td>Joints</td>
<td>1201.3.2.10</td>
</tr>
</tbody>
</table>

Note: AWS A5.31M/A5.31 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
For Sections 315.0 through 316.2.5, the UMC currently refers to the UPC for the installation of water-supplied systems to mechanical equipment. Because they are not potable systems, inspectors and installers are not following the proper methods of installing copper pipe and tubing. Fluxes used for soldering copper pipe or tubing and fittings must meet the requirements of ASTM B813. Fluxes that do not comply with ASTM B813 are used and the residue that is left in the system is aggressive, and the copper is not oxidized.

For proposed changes to Section 1201.3.2.10, this proposal removes improper terms and adds language to aid the end user.
This proposal relocates existing sections, clarifies proper terminology for brass and bronze alloys, incorporates proper joining and installation methods for copper pipe or tubing and fittings. In addition, two new standards are added for fluxes used for soldering and brazing copper pipe and tubing. Fluxes that do not comply with ASTM B813 and AWS A5.31 may result in residue that is too aggressive in the system.

In Table 1201.3.1, brass and bronze are copper alloys. Moving the standards under the applicable heading eliminates outdated language and provides the appropriate terminology and correct information to the end user. ASTM F1974 is a fitting used with plastic tubing and is already listed under the proper plastic fitting table.

**COMMITTEE ACTION:** Accept as Amended by the TC

Amend proposal as follows:

315.0 **Water Supply Material.**
315.1 **General Pipe, Tube, and Fittings.** Water supply and backflow protection shall be in accordance with the Uniform Plumbing Code. Pipe, tube, and fittings used as supply, drain, hydronics, blowdown, overflow, relief, condensate, or other similar systems shall be of material approved for such use and shall be rated for the operating temperatures and pressures of the system.

315.2 **Copper Tube.** Copper tube shall have a weight of not less than Type L.

Exception: Type M copper tubing shall be permitted to be used where piping is aboveground in, or on, a building or underground outside of structures.

315.3 **Hard-Drawn Copper Tubing.** Hard-drawn copper tubing for water supply and distribution, in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

316.0 **Copper and Copper Alloy Joints and Connections.**
316.1 **Brass Copper and Copper Alloy Pipe and Joints.** Joining methods for brass copper and copper alloy pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 316.1.1 through Section 316.1.3.

316.2.4 **1201.3.3.3 Welded Joints.** Welding shall be performed in accordance with nationally recognized standards by certified welders.

316.2.5 **1201.3.3.4 Flanged Joints.** Flanged joints shall be tightened evenly and provided with approved nuts, bolts, and gaskets.

316.8 **Copper and Copper Alloy.** Copper and copper alloy pipe, tube and fittings shall have a weight of not less than Type L.

Exception: Type M copper tubing shall be permitted to be used where piping is aboveground in, or on, a building or underground outside of structures.

316.9 **Hard-Drawn Copper and Copper Alloy Tubing.** Hard-drawn copper and copper alloy tubing for water supply and distribution, in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

1201.3.2 **Materials and Construction.** Pipe shall be brass, copper, copper alloy, cast-iron, galvanized or black wrought iron, galvanized or black steel, or other approved materials.

1201.3.2.1 **Tubing.** Tubing shall be copper water tube.

1201.3.2.2 **Valves.** Valves no more than 2 inches (50 mm) in size shall be brass, malleable iron, or steel bodies. Each gate valve shall be a full-way type with working parts of noncorrosive metal.

1201.3.2.3 **Fittings.** Plain screwed fittings shall be brass, copper, copper alloy, bronze, cast-iron, galvanized or black malleable iron, or galvanized or black steel.

1201.3.2.4 **Copper Tubing.** Fittings for copper tubing shall be wrought copper, wrought bronze, or cast brass.

1201.3.4.72.5 **Mechanically Formed Tee Fittings.** Mechanically extracted collars shall be formed in a continuous operation consisting of drilling a pilot hole and drawing out the tube surface to form a collar having a height not less than three times
the thickness of the branch tube wall. The branch tube shall be notched to comply with the inner curve of the run tube and have two dimple/depth stops to ensure that penetration of the branch tube into the collar is of an approved depth for brazing and that the branch tube does not obstruct the flow in the main line tube. Dimple or depth stops shall be in line with the run of the tube. The second dimple shall be ¼ of an inch (6.4 mm) above the first and shall serve as a visual point of inspection.

Joints shall be brazed in accordance with Section 212.0. Soft soldered joints shall not be allowed.

1201.3.2.10 Fluxes. Fluxes for soldering shall be applied to the pipe and fittings and shall be in accordance with ASTM B813, and shall become noncorrosive and nontoxic after soldering. Soft soldered joints shall not be allowed.

1201.3.3 Fabrication of Joints. Joints shall be made by the use of fittings except as otherwise permitted in this chapter.

1201.3.3.1 Screwed Joints. Threads on iron pipe size (IPS pipe) shall be standard taper pipe threads. Burrs shall be removed. Pipe ends shall be reamed or filed out to the full size of bore, and chips shall be removed.

1201.3.3.2 Solder Joints. Surfaces to be joined by soldering shall be cleaned bright by manual or mechanical means. The joints shall be fluxed using a listed soldering flux. (See standards for soldering fluxes in Chapter 17). Tubing shall be reamed out to the full size of bore.

1201.3.3.5 Mechanical Joints. Mechanical joints shall comply with nationally recognized standards.

1201.3.4 Joints and Connections.

1201.3.4.1 Brass and Copper and Copper Alloy Piping. Pipe, tubing, and fitting joints and connections shall be installed in accordance with Section 315.1. Joints in brass and copper piping shall be threaded, brazed, soldered, grooved, pressed, flared, compression, welded, flanged, or mechanically formed tee type.

1201.3.4.7 Copper Tubing. Joints in copper tubing shall be soldered, brazed, grooved, pressed, flared, or compression except that joints under a building and in or under a concrete slab resting on the ground shall be brazed, or equal, and fittings shall be of wrought copper. Mechanically formed tee fittings are also acceptable where brazed and installed in accordance with Section 1201.3.2.5. Soldered joints shall be made with solders meeting the standard for solder metal found in Chapter 17. Where steam pressures exceed 15 psig (103 kPa) or water pressures exceed 30 psig (207 kPa), then 50 percent tin-50 percent lead solder shall not be used. Solders and fluxes with a lead content which exceeds two-tenths of 1 percent shall be prohibited in piping systems conveying potable water.

1201.3.4.8 Piping to Tubing. Joints connecting piping to tubing shall be made with adapter fittings connected as required in Section 1201.3.4.1 through Section 1201.3.4.7.

<table>
<thead>
<tr>
<th>TABLE 1201.3.1</th>
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<tbody>
<tr>
<td>MATERIALS</td>
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<td>Bronze</td>
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</table>

(portion of table not shown remains unchanged)

<table>
<thead>
<tr>
<th>TABLE 1701.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD NUMBER</td>
</tr>
<tr>
<td>AWS A5.31M/A5.31-2012</td>
</tr>
</tbody>
</table>

(portion of table not shown remains unchanged)
COMMITTEE STATEMENT:
In Section 315.1, the text “Water supply and backflow protection shall be in accordance with the Uniform Plumbing Code” should not be deleted in favor of Item # 063. Section 315.2 and Section 315.3 were relocated to Section 316.8 and Section 316.9 for clarity and references to “brass” were revised to “copper and copper alloy” as it is the correct terminology used in the industry. Furthermore, all Chapter 12 revisions were rejected in favor of Item # 314 and Item # 315.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Tim Ross, Ross Distributing, Inc.

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
This proposal creates confusion as the requirements are in conflict with the joint and connection provisions addressed in Chapter 11 (Hydronics). Furthermore, Chapter 3 addresses general requirements, which apply to the entire code, including Chapter 11. Therefore, this proposal should be rejected to avoid any confusion and ambiguity.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of materials used for piping, tubing, and fittings.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I agree with the commenter. It is confusing to have the same requirements in two sections, not to mention hard to maintain and keep consistent. The water supply is a plumbing item so it will be addressed in the plumbing code. If for some reason it is deemed to be a hydronic system that falls under the mechanical code, Chapter 12 applies. There is no need for all this repetition.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 316 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

315.0 Plumbing Connections.
315.1 Pipe, Tube, and Fittings General. Water supply, sanitary drainage, and backflow protection shall be in accordance with the plumbing code. Pipe, tube, and fittings used as supply, drain, hydronics, blowdown, overflow, relief, condensate, or other similar systems shall be of material approved for such use and shall be rated for the operating temperatures and pressures of the system.
315.2 Copper Tube. Copper tube shall have a weight of not less than Type L.
316.0 Copper and Copper-Alloy Joints and Connections.

316.1 Copper and Copper-Alloy Pipe and Joints. Joining methods for copper and copper-alloy pipe and fittings shall comply with Section 316.1.1 through Section 316.1.3.

316.1.1 Brazed Joints. Brazed joints between brass pipe and fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). 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. An approved brazing flux shall be applied to the joint surfaces where required by manufacturer’s recommendation. The joint shall be brazed with a brazing filler metal in accordance with AWS A5.8. Brazing filler metal shall be applied at the point where the pipe or tubing enters the socket of the fitting.

316.1.2 Mechanical Joints. Mechanical joints shall be installed in accordance with the manufacturer’s instruction. Joints shall include compression, flanged, grooved, press, and threaded.

316.1.3 Threaded Joints. Threads shall comply with ASME B1.20.1. Pipe joint compound or tape shall be applied on the male threads only.

316.2 Copper Pipe, Tubing, and Fittings. Joints between copper or copper-alloy pipe, tubing, and fittings shall comply with Section 316.2.1 through Section 316.2.3.

316.2.1 Brazed Joints. Brazed joints between copper or copper-alloy pipe and fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). 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. An approved brazing flux shall be applied to the joint surfaces where required by manufacturer’s recommendation. The joint shall be brazed with a brazing filler metal in accordance with AWS A5.8. Brazing filler metal shall be applied at the point where the pipe or tubing enters the socket of the fitting.

316.2.2 Mechanical Joints. Mechanical joints shall include, but are not limited to, compression, flanged, grooved, press, and threaded, and push-fit fittings.

316.2.2.1 Mechanically Formed Tee Fittings. 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. The joint shall include, but are not limited to, compression, flanged, grooved, press, and threaded, and push-fit fittings.

316.2.2.2 Pressed-Connect Joints. Pressed fittings for copper pipe or tubing shall have an elastomeric O-ring that forms the joint. The joint shall be pressed using the tool recommended by the manufacturer. Soldered fittings shall not be permitted.

316.2.2.3 Push-Connect Joints. Removable and non-removable push-fit fittings for copper pipe or tubing that employ quick assembly push-fit connectors shall be in accordance with ASSE 1061. Push-fit fittings for copper 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 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.

316.2.3 Soldered Joints. Soldered joints between copper pipe or tubing and fittings shall be made in accordance with the methods of ASTM B828 with the following sequence of joint preparation and operation as follows: measuring and cutting, reaming, cleaning, fluxing, assembly, and support, heating, applying the solder, cooling, and cleaning. 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 and tubing. Surfaces to be joined shall be cleaned bright by manual or mechanical means. Flux shall be applied to the 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 joint.
fitting and remove excess flux. Pipe or tubing and fitting shall be supported to ensure a uniform capillary space around the joint. Heat shall be applied using an air or fuel torch with the flame perpendicular to the pipe or tubing using acetylene or an LP gas. Preheating shall depend on the size of the joint. The flame shall be moved to the fitting cup and alternate between the pipe or tubing and fitting. Solder in accordance with ASTM B32 and 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.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
1. The plumbing connections requirements in Section 315.1 (Pipe, Tube, and Fittings) through Section 312.3 (Hard-Drawn Copper Alloy Tubing) are outside the scope of the UMC as water supply, sanitary drainage, and backflow prevention are within the purview of the UPC. Furthermore, the requirements added to the UMC (Section 515.2 and Section 315.3) use language obtained directly from Section 604.2 (Copper or Copper Alloy Tube) and Section 604.3 (Hard-Drawn Copper or Copper Alloy Tubing) of the UPC which are only applicable for water supply and distribution.

2. The language in Section 316.0 through Section 316.2.3 of the UMC do not correlate with the language found in the UPC (Section 601.1 through 605.1.5) for copper or copper alloy pipe, tubing, and joints.

3. The material requirements added in Chapter 3 creates inconsistencies and conflicts throughout the code. The language is in conflict with ASHRAE 15, ASME B31.5, and Chapter 13 (Section 1308.5.10.1) which is an NFPA 54 extraction. Other examples of conflicts are as follows:
   a. For example, Section 316.2.3 will permit the use of solder throughout the code, and Section 1308.5.10.1 only permits brazing to be used for fuel gas piping. Furthermore, Chapter 11 only permits soldering to be used only for refrigeration systems with Group A1 refrigerants.
   b. ASHRAE 15 only allows Type K and Type L to be used for unprotected piping, and Section 312.3 will permit Type M to be used which is now in conflict with ASHRAE 15.
   c. Chapter 11 (Section 1109.1.1 and Section 1109.1.2) indicates that refrigerant piping shall be in accordance with ASME B31.1. However, ASME B31.1 contains joining methods that are not permitted for all refrigerant-type systems which will be in conflict with the added provisions in Item # 316. The type of joining method is dependent on the type of refrigerant system is being used and are not applicable to all types of refrigeration systems.
   d. The provisions in Chapter 3 are repetitive to the joints and connections provisions that already addressed in Chapter 12 which will create confusion in the field in regards to enforcement and application.

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on Section 315.1 through Section 316.2.3.
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.

1201.3.2.2 Valves. Valves no more than 2 inches (50 mm) in size shall be brass, malleable iron, or steel bodies. Each gate valve shall be a full-way type with working parts of noncorrosive metal.

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.

SUBSTANTIATION:
Isolation valves are necessary in hydronic 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. Draining a water hydronic system causes air to enter the system, and will require that fresh water be introduced to refill the system. The time-consuming process of purging and bleeding air from the system and the corrosion problems associated with new water make it desirable to avoid system draining whenever possible. In order to change the tank air charge pressure it is necessary to isolate the tank circuit from the main system piping. A high quality, gate type, lock-shield valve (isolation valve) must be used for this purpose.

COMMITTEE ACTION: Accept as Submitted
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:

SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:

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

SUBSTANTIATION:

The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:

1. For Section 1212.2, Section 1212.3, and Section 1212.6 valves are not always needed right at the heat exchanger. If a dedicated pump is included, the valve would also isolate the dedicated pump. Perhaps there should be a requirement of so many feet between valve and appliance.
2. Section 1212.7 conflicts with the proposed Section 1209.0.
3. Section 1212.10 is too vague and unenforceable. Thermosiphoning is seldom an issue on modern systems with control valves.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:

The public comment removes provisions that are necessary for the enforcement of valves used in hydronic systems.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

TAYLOR: The following sections should be revised as follows:

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. Isolation valves shall be installed in hydronic piping systems in accordance with Section 1212.3 through Section 1212.11 for the hydronic system components listed below to permit cleaning, inspection, or repair without shutting down or draining other parts of the system:

1. Serviceable equipment, components, and appliances
2. Pumps and circulators
3. Pressure reducing valves
4. Air removal devices and air vents

Exception: Equipment and components interconnected with piping less than 10 feet (3 meters) may be isolated as an assembly.

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.

Rationale:

- The primary revision is to clean up the format to avoid repetition. Focus is to isolating equipment for service and not to other valve types which really are not issues that should be addressed by code.

- Flow balancing is eliminated because it did not say anything.

- Mixing valves are eliminated because again it did not say anything.

- Thermosiphoning is almost never a problem in hydronic systems and where it is, the engineer can address it. As stated above, it says nothing substantive.
SUBMITTER:  Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 13)

RECOMMENDATION: 
Add new text as follows:

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 Radiant Floor Heating Panels. Radiant floor heating panels shall be protected with a high-limit control set 20°F (-6.7°C) above the maximum design water temperature for the panel to prevent the introduction of heat into the panel. The high-limit setting shall not exceed the temperature rating for the pipe and shall be equipped with a manual reset. 
1213.3 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.  
1213.3.1 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. 
1213.4 Occupied Spaces. An air-temperature-sensing device shall be installed in the occupied space to regulate the operation of the heat-distribution system. 
1213.5 Return-Water Low-Temperature Protection. Where a minimum return-water temperature to the heat source is specified, the heating system shall be designed and installed to ensure that the minimum return-water temperature is maintained during the normal operation of the heat source. 

SUBSTANTIATION: 
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 must be avoided. 

COMMITTEE ACTION: Accept as Submitted 

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION. 
PUBLIC COMMENT 1:  
SUBMITTER: Harvey Kreitenberg, Harvey Kreitenberg & Associates 

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

1213.6 Simultaneous Operation. Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling. 
1213.7 Temperature Reading. A temperature gauge or transmitter shall be installed for reading the following fluid temperatures: 
(1) The panel system supply and outlet. One temperature gauge or transmitter shall be permitted where the temperature between the heat source outlet and panel system supply are the same. 
(2) The heat source outlet and return line. One temperature gauge or transmitter shall be permitted where the temperature between the panel system outlet and the heat source return are the same.
SUBSTANTIATION:
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, Section 1213.6 and Section 1213.7 correlates with similar provisions submitted for the 2015 USEHC, which was accepted by the USEHC Technical Committee.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed language would introduce a concept that has not had a public review by being included in a related proposal as published in the ROP.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 318 (Public Comment 1) and USEHC Item # 045 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

1213.6 Simultaneous Operation. Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling.

1213.7 Temperature Reading. A temperature gauge or transmitter shall be installed for reading the following fluid temperatures:
(1) The panel system supply and outlet. One temperature gauge or transmitter shall be permitted where the temperature between the heat source outlet and panel system supply are the same.
(2) The heat source outlet and return line. One temperature gauge or transmitter shall be permitted where the temperature between the panel system outlet and the heat source return are the same.

TCC COMMITTEE ACTION: Reject

TCC COMMITTEE STATEMENT:
The TCC believes that Section 1213.6 and Section 1213.7 are not applicable to the UMC and therefore should not be added to the UMC. Furthermore, the addition of Section 1213.6 and Section 1213.7 were rejected by the UMC TC and the TCC agrees with the UMC TC that the proposed language has not had a public review as it introduces a new concept which was not included in a related proposal as published in the ROP.

The new Section 1213.6 and Section 1213.7 of the UMC will correlate with the action taken by the USEHC TC to “accept as submitted” Item # 045.

The substantiation provided by the USEHC for accepting Item # 045 is as follows:
“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.”
The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on Section 1213.6 and Section 1213.7 in regards to simultaneous operation and temperature reading for hydronic systems.

PUBLIC COMMENT 2:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

1213.2 Radiant Floor Heating Panels. Radiant floor heating panels shall be protected with a high limit control set 20°F (-6.7°C) above the maximum design water temperature for the panel to prevent the introduction of heat into the panel. The high-limit setting shall not exceed the temperature rating for the pipe and shall be equipped with a manual reset.

(renumber remaining sections)

SUBSTANTIATION:
The provision in Section 1213.2 is going to create unnecessary nuisance shut downs of heating systems. Most new systems may have up to three different operating temperatures requirements ranging anywhere from 90°F to 180°F. PEX tubing is capable of withstanding 200°F operating temperatures. Lower water temperatures are achieved through any one of numerous existing accepted methodologies for reducing the fluid temperature to a give radiant panel if other non-radiant demands are concurrently being called for by a given system design.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
Section 1213.2 should not be deleted as it is necessary for the enforcement of radiant floor heating panels.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• Section 1213.0 is “heating-system-centric” rather than addressing all hydronic systems. At best it is incomplete.
• Energy standards already address space temperature controls and simultaneous heating and cooling restrictions. This is not an energy standard.
• Chapter 9 and Chapter 10 address equipment safety controls already.
• Furthermore, the language is vague and says nothing substantive. It basically says to “install controls to control things.” There is no meat just a lot of words that add bulk to the code.

PUBLIC COMMENT 3:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.
SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed. For example, Section 1213.0 is “heating-system-centric” rather than addressing all hydronic systems. Furthermore, the language is vague and meaningless. Energy standards address controls from an energy perspective. Chapter 9 and Chapter 10 address safety controls. Do we really need this section? Section 1213.0 through Section 1213.5 should be deleted.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of the section. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• Section 1213.0 is “heating-system-centric” rather than addressing all hydronic systems. At best it is incomplete.
• Energy standards already address space temperature controls and simultaneous heating and cooling restrictions. This is not an energy standard.
• Chapter 9 and Chapter 10 address equipment safety controls already.
• Furthermore, the language is vague and says nothing substantive. It basically says to “install controls to control things.” There is no meat just a lot of words that add bulk to the code.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 14)

RECOMMENDATION:
Add new text as follows:

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 not be required. An external cut-off device shall be installed in accordance with the heat-source manufacturer’s installation instructions. A 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 Water. Where an automatic makeup water 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. A pressure-reducing valve shall be installed on the makeup water feed line. The pressure of the feed line shall be set as specified in 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 zone flows 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 pump.

1214.5.1 Differential Pressure Bypass Valve. Where a differential pressure bypass valve is used for the purpose specified in Section 1214.4, it shall be installed and adjusted to provide bypass of the distribution system where the zones are closed.

1214.6 Air-Removal Device. Provision shall be made for the removal of air in the heat-distribution piping system. The air-removal device shall be located in the area of the heat-distribution piping system where air accumulates. Air-removal devices shall be installed to facilitate their removal for examination, repair, or replacement.

1214.7 Air-Separation Device. An air-separation device shall be installed on a closed heat-distribution system. The device shall be located in accordance with the manufacturer’s installation instructions or at the point in the heat-distribution system where there is no pressure change and the water in the heat-distribution system is at the highest temperature.

1214.8 Secondary Loops. Secondary loops that are isolated from the primary heat-distribution loop by a heat exchanger shall have an air-removal device or an air-separation device as specified in Section 1214.6 or Section 1214.7.

SUBSTANTIATION:
Hydronic 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.

The sole purpose of a low-water cut-off control is to stop the heat input to the direct-fired heat source whenever the water level is dangerously low. These devices automatically interrupt the power supply to the burner controls or heating elements to cause the direct-fired source to shutdown. A pumped condensate return must have a switch in the low water cutoff that signals the pump when the heat source needs water. If there is inadequate condensate coming back from the system, the make-up valve opens and brings the water up to the required level to ensure that there will always be a reservoir of water for the pump.
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.

Hydronic systems normally require a means of supplying fill and makeup water to replace any water lost to evaporation, leakage, or intentional draining. Where the system is connected directly to the potable water supply, the connections must be isolated from the potable water source.

Provisions must be made to control zone flows in a multi-zone hydronic system where the closing of some or all of the two-way zone valves cause excess flow through the open zones or deadheading of a fixed-speed pump. The variance of flow must be accommodated so when zones close down, the open zones do not receive excess flow or pressure and fixed-speed pumps do not dead head. The intent is to protect systems that use zone valves from over pressure or high flow when zones close, typically fixed-speed circulators will develop more head pressure when volume of flow is decreased. Also it is important to prevent circulators from deadheading. The intent of the bypass valve is to avoid the undesirable pressure effect described above.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT 1:
SUBMITTER: Piotr Zelasko, Radiant Professionals Alliance/Rep. USEHC Working Group

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

1214.4 Automatic Makeup Water. Where an automatic makeup water 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.

A pressure-reducing valve shall be installed on the makeup water feed line. The pressure of the feed line shall be set as specified in the design of the system, and connections to potable water shall be in accordance with Section 1202.0 to prevent contamination due to backflow. Systems containing antifreeze shall not have an automatic makeup water connection. Pressure shall be maintained in antifreeze induced systems with an approved self contained glycol reservoir or makeup system. Antifreeze induced systems shall be protected against dry operation through the use of a low-pressure cut off device. Automatic glycol makeup system shall have an audible low-fluid level alarm to notify the system operator when the replenishing fluid is inadequate.

SUBSTANTIATION:
Snowmelt systems and space heating systems protected with antifreeze solutions can experience inadvertent dilution and subsequent pipe and component failure due to the percentage of antifreeze becoming diluted from leaking pressure relief valves, or from pressure relief valves that inadvertently discharge. Such leakage or discharge will require additional makeup water in order to maintain required minimum operating pressures. Eliminating the potable water makeup requirement, and substituting the use of commonly available glycol reservoir makeup packages, will avert expensive piping failures when exposed to freezing conditions.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected as the proposed language is overly restrictive and does not cover all types of systems.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
PUBLIC COMMENT 2:
SUBMITTER: Jeff Matson, Viega LLC

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

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 where the zones are closed.

SUBSTANTIATION:
The reference to Section 1214.4 in Section 1214.5.1 is a typo and it should be Section 1214.5, as Section 1214.5.1 pertains to the use of differential bypass valves for flow regulations, and not the automatic fill valves of Section 1214.4 which are a different type of component function. Furthermore, a differential pressure bypass valve is not intended to serve as an automatic makeup water fill valve.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE 21 NOT RETURNED: 1 Garza

PUBLIC COMMENT 3:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

Some examples of issues are:
(1) Section 1214.0 is “heating-system-centric” rather than addressing all hydronic systems.
(2) Section 1214.2 is redundant as it is already addressed in Table 1003.2.1.
(3) Section 1214.3 should refer to the manufacturer’s listing as not all boilers require flow switches.
(4) Section 1214.4 is not necessary as makeup water does not need to be located at the expansion tank.
(5) Section 1214.5.1 is not enforceable.
(6) Section 1214.7 and Section 1214.8 will require air separators, which is definitely not needed on any hydronic system and not useful on those that seldom open like most chilled water systems. Also, there are no sections in a hydronic system where there is no pressure change; it should be the section of lowest pressure.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected as it removes provisions that are necessary to enforce the methods used for pressure and flow control in a hydronic system.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• Section 1214.0 is “heating-system-centric” rather than addressing all hydronic systems.
• Section 1214.1 is not needed. Balancing is already covered in Section 317
• Section 1214.2 is not needed. Low water controls are already addressed in Sections 904.5, 1009, 1010, 1011, and Table 1011.1 in much more detail.
• Section 1214.3 is covered by manufacturer’s listings. Not all boilers require flow switches.
• Section 1214.4. is technically incorrect: makeup water does not need to be located at the expansion tank. Backflow protection of potable water is covered in the plumbing code and in Section 315.1.
• Section 1214.5 is not enforceable and a complex design detail that should not be addressed by the code.
• Section 1214.6 and Section 1214.7 will require air separators, which is definitely not needed on any open hydronic system and not useful on those that seldom open like most chilled water systems. Also, there are no sections in a hydronic system where there is no pressure change; it should be the section of lowest pressure. Also air removal devices need not be installed at the ideal location (lowest pressure, highest temperature) to be effective so this should not be mandatory as it is not always possible.
• Overall, this proposed section is littered with technical errors.
Item # 320  
UMC 2015 – (1215.0 – 1215.5):

SUBMITTER: Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 15)

RECOMMENDATION:
Add new text as follows:

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 heat-distribution units or other system 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 Medium. The flash point of a transfer fluid in a hydronic piping system shall be a minimum of 50°F (10°C) above the maximum system operating temperature. The transfer fluid shall be compatible with the makeup water supplied to the system.

SUBSTANTIATION:
Selection of heat distribution units is to ensure that equipment is incorporated into hydronic heating systems in a manner that meets the needs of the design. While taking into consideration the requirements, specifications of the manufacturer, and for supply temperatures to be compatible with the selected heat distribution unit. If a heat transfer fluid with a low flash point is used in a hydronic system a pressure relief valve discharge or a system leak may create a potential hazard. To avoid this possibility, the flash point of the transfer fluid must be at least 50°F higher than the maximum possible temperature at which the system can operate. Protection from freezing is essential for heat-distribution units as they are typically located on outside walls. Every hydronic system and terminal within a hydronic system operates more effectively when balanced correctly. With this control comes the best possible indoor climate as the lowest possible energy cost.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed. For example, Section 1215.5 would preclude the use of hot-water systems above (212°F - 50°F) = 162°F. The vast majority of commercial heating systems use 160°F to 180°F water.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment is being rejected as it removes provisions that are necessary for the enforcement of hydronic space heating

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• Section 1215.1 and 1215.2 say nothing substantive.
• Section 1215.3 freeze protection is addressed in 1210.1 already.
• Section 1215.4 is not needed. Balancing is already covered in Section 317
• Section 1215.5 will outlaw the vast majority of heating hot water systems. It would preclude the use of hot-water systems above \((212^\circ F - 50^\circ F) = 162^\circ F\). The vast majority of commercial heating systems use 160°F to 180°F water. To comply at these normal temperatures, glycol would have to be added. That has a negative energy and environmental impact and clearly is not something that should be required without some justification. If “flash point” refers to the boiling point at the pressure the system operates at, then compliance could be achieved by raising the system pressure. But why does raising the pressure make the system safer? It would seem to make it less safe. No rationale is provided for what the safety advantage is of this requirement.
REVISE TEXT AS FOLLOWS:

**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 \( \frac{1}{8} \) 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 \( \frac{1}{8} \) 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. Steam traps shall be installed on pump and receiver condensate systems to eliminate negative pressures in coils and heat exchangers on a low-pressure steam system. Air vents shall not be used on a vacuum system.

**1216.5 Condensate Flow.** System piping shall be installed to allow condensate to flow from the steam trap to the condensate tank or steam boiler.

**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.

**1201.3.8.4 Circulation.** Piping shall provide approved circulation. Piping shall be graded so that gases are capable of moving in the direction of the water flow to a vented section of the system. Where sections of a piping system cannot be installed with the required grade, such sections shall be provided with automatic or manual air vents whose discharge is piped to an approved location. Steam traps shall be provided where required.

**SUBSTANTIATION:**

Steam traps are required for pumped condensate systems to eliminate negative pressures in units such as coils, radiators and heat exchangers. Where multiple rows of heating elements are in one enclosure, each row must have a steam trap. The steam must be fed from the top down. This type of arrangement will ensure the condensate can flow back to the boiler or receiving tank. Gravity steam systems require air vents to release air pressure from within the system.

**COMMITTEE ACTION:** Accept as Submitted

**A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**

**PUBLIC COMMENT:**

**SUBMITTER:** Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

**RECOMMENDATION:**

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

**SUBSTANTIATION:**

The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently
eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement steam systems. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
1217.0 Radiant Heating and Cooling.
1217.1 Installation. Radiant heating and cooling panels shall be installed in accordance with the system design.

Part II—Hydronic Panel Heating Systems.
1202.0 Scope.
1202.1 General. The purpose of this part is to establish and provide minimum standards for the protection of public health, welfare, and property by regulating and controlling the design and installation of panel heating systems.

1203.0 Installation.
1203.1 Design and Installation. Panel systems shall be designed and installed in accordance with installation standards incorporated in Chapter 17 and the requirements of this code.

1217.2 Radiant Under-Floor Heating. Floor surface temperatures shall not exceed the following temperatures:
(1) 85°F (29°C) in dwellings, buildings, or structures.
(2) 85°F (29°C) in occupancies where prolonged foot contact with the floor, and solid or laminated hardwood flooring.
(3) 90°F (32°C) in bathrooms and indoor swimming pools.

The radiant heating panel temperature shall not exceed the maximum temperature rating of the materials used in the construction of the radiant heating panel. The radiant panel shall be protected with a high-limit control in accordance with Section 1213.2.

1217.3 Chilled Water Systems. Chilled water systems for cooling shall be designed to minimize the potential for condensation. Chilled water piping, valves, and fittings shall be insulated and vapor sealed to prevent surface condensation.

1217.4 Dehumidification. A chilled ceiling or chilled floor panels used for space cooling shall be installed in a humidity-controlled environment. An air handling device that removes humidity shall be incorporated into the system to keep the relative humidity below 70 percent. A humidity sensor shall be installed within the space to turn off the panels where the surface approaches the dew point.

1217.5 Tube Placement. Hydronic radiant panel tubing shall be installed in accordance with the manufacturer's installation instructions and system design. The 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 1217.5. Actual loop lengths shall be determined by spacing, number of loops, 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.

In a single-zone multiple-manifold installation, balanced flow through manifolds shall be as specified in Section 1215.4.

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<thead>
<tr>
<th>NOMINAL TUBE SIZE</th>
<th>MAXIMUM LOOP LENGTH</th>
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<tbody>
<tr>
<td>(inches)</td>
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<td>3/4</td>
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For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm
1217.6 Poured Floor Systems (Thermal Mass). Where tubing is embedded in a 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. The top of the tubing shall be embedded in the slab not less than 2 inches (51 mm) below the surface.

1217.6.1 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 a protective pipe sleeve. The space between the tubing and sleeve shall be sealed. 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 expansion joint or the tubing shall be installed below the slab.

1201.3.2.15 Sleeves. Sleeves shall be of steel, cast-iron or wrought-iron pipe, or tile.

1201.3.2.9 Protective Coatings. Protective coatings shall be watertight, durable, heat resistant, electrically nonconductive, and tightly adherent to the pipe.

1217.6.2 Insulation. Where a poured concrete radiant floor system is installed in contact with the soil, not less than R-5 insulation shall be installed and shall be placed between the soil and the concrete; extend to the outside edges of the concrete; and be placed on all slab edges.

Where a poured concrete radiant floor system is installed on grade, not less than R-5 insulation shall be installed and placed on vertical slab edges.

Where a poured concrete radiant floor system is installed within a habitable space above and below, the total R-value of the floor system below the concrete slab shall be greater than the total R-value of the material lying above the concrete slab and the floor system shall have not less than a R-3 value.

1217.6.3 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.

An air space of not less than 2 inches (51 mm) shall be maintained between the top of the insulation and the underside of the floor unless a conductive plate is installed.

Where tubing is installed above or in the subfloor and not embedded in concrete, the floor assembly shall be insulated with not less than R-12 material below the tubing.

1217.6.4 Wall and Ceiling Panels. Where piping is installed in the wall stud 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 2 inches (51 mm) shall be maintained between the insulation and the interior surface of the panel unless a conductive plate is installed.

SUBSTANTIATION:
The temperature of the water flowing through the tube is based on the amount of material obstructing the movement of heat from the tube to the space being heated. The type of flooring used, or extra floor material that the heat must pass through, will require higher water temperatures to motivate the flow of heat into the space.

Tube placement is determined by the spacing, flow rate, friction loss, and pump capability identified in the design. The intent is to ensure excessively long tubing lengths are not used in panel systems. Identification and labeling is an important part of radiant panel tube heating in order to provide proper system balancing.

Some differences between heating and cooling systems are the necessity of constant supply water temperature for humidity control; constant circulation rates because of chiller low temperature and freeze point requirements; relative small water temperature ranges because of the series of temperature differentials required between the water freeze point and dehumidification. Whether a chilled ceiling or chilled floor is used for space cooling, both systems need to be in a humidity-controlled environment. Therefore, some type of air-handling device that removes humidity must also be incorporated into the system to keep the relative humidity below 70 percent.
Good design practices consider the effects of tube placement. Where tubes are placed closer together the result is a lower water temperature. Bare concrete and tile floors may suffer from "striping" when tube centers are too far apart. The results of striping (warm and cool bands) can be felt on the floor surface by the occupants and should be avoided. Manufacturers should be consulted for actual "R" values and maximum temperatures for their products. Tube location near the concrete floor surface is preferred for very thick slabs, minimum of 2 inches of concrete cover to prevent cracking. R-value is a unit of measure of thermal resistance and the higher the value, the better the heat-insulating capabilities of the material. For example, an 8" lightweight concrete block has an R-value of 2 and a ½ of an inch of plywood has an R-value of .63. The concrete block has far better heat-insulating properties than the plywood. This unit is used to find the 'heat-loss calculation' for a structure so that preparations can be made to properly heat the structure. Radiant heating systems need low R-values for carpet pads to allow the heat to pass through it and high R-values are encouraged everywhere else.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:

SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:

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

SUBSTANTIATION:

The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:

The public comment removes provisions that are necessary for the enforcement of radiant heating and cooling systems. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:

TAYLOR: This proposal has several technically incorrect provisions. Furthermore, the following sections should be revised as follows:

1217.0 Radiant heating and Cooling.

1217.1 Installation. Radiant heating and cooling panels shall be installed in accordance with the system design.

1217.21 Radiant Under-Floor Heating. Floor finished surface temperatures shall not exceed the following temperatures for comfort heating applications:

(1) 85°F (29°C) in dwellings, buildings, or structures general.

(2) 85°F (29°C) in occupancies where prolonged foot contact with the floor, and solid or laminated hardwood floor-
90°F (32°C) in bathrooms and indoor swimming pools.

The radiant heating panel system temperature shall not exceed the maximum temperature rating of the materials used in the construction of the radiant heating panel system. The radiant panel system shall be protected with a high-temperature limit control in accordance with Section 1213.2.

1217.2 Chilled Water Radiant Systems. Chilled water radiant systems shall be designed to minimize the potential for condensation including one or more of the following:

1. An air dehumidification system is provided to maintain space dewpoint temperature below the surface temperature of the radiant cooling surface;
2. Chilled water temperature is controlled to maintain the temperature of the radiant cooling surface above space dewpoint temperature;
3. An engineered system approved by the Authority Having Jurisdiction.

Where chilled water temperature is controlled to be below space or ambient dewpoint temperature, chilled water piping, valves, and fittings shall be insulated and vapor sealed to prevent surface condensation.

1217.4 Dehumidification. A chilled ceiling or chilled floor panel used for space cooling shall be installed in a humidity-controlled environment. An air handling device that removes humidity shall be incorporated into the system to keep the relative humidity below 70 percent. A humidity sensor or other approved device shall be installed within the space provided to turn off the panels radiant cooling system when the surface approaches the dew point temperature and humidity conditions are such that condensation will occur on the radiant cooling surface.

1217.3 Tube Placement. Hydronic radiant panel tubing shall be installed in accordance with the manufacturer’s installation instructions and system design. The 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 1217.3. Actual loop lengths shall be determined by spacing, number of loops, 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.

In a single-zone multiple-manifold installation, balanced flow through manifolds shall be as specified in Section 1215.4:

<table>
<thead>
<tr>
<th>NOMINAL TUBE SIZE (inches)</th>
<th>MAXIMUM LOOP LENGTH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>¼</td>
<td>125</td>
</tr>
<tr>
<td>⅝</td>
<td>200</td>
</tr>
<tr>
<td>⅛</td>
<td>250</td>
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<tr>
<td>⅜</td>
<td>300</td>
</tr>
<tr>
<td>½</td>
<td>400</td>
</tr>
<tr>
<td>¾</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

1217.6 Poured Floor Concrete Slab Systems (Thermal Mass). Where tubing is embedded in a 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 (3 m) of the distribution manifold. The top of the tubing shall be embedded in the slab not less than 1.52 inches (38 mm) below the surface unless approved by the tubing manufacturer, concrete floor designer, and Authority Having Jurisdiction.

1217.6.1 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 a protective pipe sleeve. The space between the tubing and sleeve shall be sealed. 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 expansion joint or the tubing shall be installed below the slab.
4217.6.3 1217.4.2 Insulation. Where a poured concrete radiant floor system is installed in contact with the soil, not less than R-5 insulation shall be installed and shall be placed between the soil and the concrete; extend to the outside edges of the concrete; and be placed on all radiant slab edges.

Where a poured concrete radiant floor system is installed on grade, not less than R-5 insulation shall be installed and placed on vertical slab edges.

Where a poured concrete radiant floor system is installed within a habitable space above and below, the total R-value of the floor system below the concrete slab shall be greater than the total R-value of the material lying above the concrete slab and the floor system shall have not less than a R-3 value.

1217.6.3 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. An air space of not less than 2 inches (51 mm) shall be maintained between the top of the insulation and the underside of the floor unless a conductive plate is installed.

Where tubing is installed above or in the subfloor and not embedded in concrete, the floor assembly shall be insulated with not less than R-12 material below the tubing.

1217.6.4 Wall and Ceiling Panels. Where piping is installed in the wall stud 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 2 inches (51 mm) shall be maintained between the insulation and the interior surface of the panel unless a conductive plate is installed.

Rationale:
- Section 1217.1 is a contractual issue, not a code issue.
- Section 1217.2 is revised to apply to both in- and under-slab systems and the word “panel” is changed to “system” since in-slab systems have no panels.
- In Section 1217.2, temperature limitations are for comfort applications; some process applications will have higher temperatures.
- In Section 1217.2, temperature for areas with “prolonged foot contact” is deleted because it is not enforceable and also because it does not matter given the temperature is the same as the general limit.
- Section 1217.3 is revised to be more enforceable and to eliminate unnecessary stringency. Many (most in my experience) systems are designed with lukewarm chilled water that is maintained above dewpoint temperature to avoid any condensation. But in mild climates, this can be done without dehumidification.
- In Section 1217.3 and Section 1217.4, using a humidity sensor as a safety to prevent condensation is actually not a good approach because humidity sensors are inaccurate and get out of calibration quickly. Other more reliable sensors include moisture sensors on piping connections. The language has been generalized accordingly.
- In Section 1217.5, references to the “system design” are a contractual issue, not a code issue.
- In Section 1217.5, references to balancing is not necessary. Balancing is already covered in Section 317.
- In Section 1217.6, changes are made to be consistent with the snow-melt language which was slightly different.
- In Section 1217.6, an exception is made for piping around the manifold where it is generally impossible to maintain the specified spacing. An example from one of our projects is shown below. The radiant zone pipes are color coded. Near the manifold, the spacing must be tight. This is true of almost all floor applications.
• In Section 1217.6, the distance from the tubing to the top of the slab is reduced to 1.5". It is extremely common for 2" slabs to be used with 0.5" tubes. This is almost standard practice. We have seen even thinner slabs but cracking does become an issue so this should be approved by the piping manufacturer, the design of the concrete floor, and the AHJ.

• In Section 1217.6.2 second paragraph, this seems no different than the first paragraph in application or requirement.

• In Section 1217.6.2 third paragraph, there is no reason for this requirement in a code. Many designs, e.g. The European Isotherm system, rely upon heat transfer to the space through both the top and the bottom of the slab. The requirement, furthermore, doesn’t make any sense. It seems to say that the insulation value of the floor system (assumed to be below the slab) shall be the greater of either R# or the insulation value of the material lying above the slab. Anyone designing a radiant slab for thermal delivery through the top of the slab would require the slab coverings to have much less than R3 insulation value. In any case, this is a design issue and not a code issue and must be deleted.

• In 1217.6.3, the first sentence says nothing substantive. The second is not technically correct; with proper water temperature control, even temperatures are possible without tight spacing and tight spacing does not guarantee even temperature since the capacity of the tubing will be larger than the load so flow will be low and the ΔT will be high causing warmer temperatures near the manifold. Once these two sentences are removed, this section and Section 1217.6.4 are about insulation and can be merged with the previous one.

• In Section 1217.6.4 last paragraph, this requirement does not make sense. There is no reason why insulation cannot touch the back of the panel and it commonly does.
Item # 323 Comment Seq # 103

UMC 2015 – (1217.7 – 1217.7.2):

SUBMITTER: Don Surrerna
National Association of Homebuilders

RECOMMENDATION:
Add new text as follows:

1217.7 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.

1217.7.1 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.

1217.7.2 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 expansion screws of sufficient size and anchorage to support the loads applied. In high moisture areas, 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.

SUBSTANTIATION:
Currently the UMC is not clear in regards to the installation of radiant heating and cooling panels. Radiant heating and cooling panels should be installed in accordance with the manufacturer’s installation instructions and be listed for the specific application. Therefore, proposed Section 1217.7 should be added to clarify to the end user of such requirements.

Section 1217.7.1 will address the minimum requirements for electric heating panel systems which are currently not addressed in the UMC. Electric heating panel systems are common throughout the industry, and the end user has no guidance for the safe installation of such system. NFPA 70 is the industry standard for many electric-type products including heating panels.

In Section 1217.7.2, will address the anchorage of radiant wall and ceiling panels. It is crucial that the panels are securely fastened to support the distributed loads. Furthermore, since it is common for panels to be exposed to areas where corrosion can occur, such installation will require the fasteners to be of corrosion-resistant material. Support of radiant panels is safety issue and should be addressed.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: Marguerite Carroll, UL, LLC

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

1217.7.1 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 Section 1222.0 through Section 1222.9.

1222.0 Electrical Radiant Heating.

1222.1 General. Electric radiant heating systems shall be capable of being switched on and off by an approved control system. Electric space heating cables and radiant panels shall comply with NFPA 70 and Section 1222.2 through Section 1222.9.

1222.2 Electric Heating Cables. Electric space heating cables shall be secured in place with corrosion-resistant material at intervals in accordance with the manufacturer’s installation instructions. Where installed on gypsum or plaster, the heat flux shall not exceed 9.38 British thermal units per hour per linear feet [Btu/h/ft] (0.009 kW/m) and shall be installed such that the spac-
ing between adjacent runs is not less than 1\(\frac{1}{2}\) inches (38 mm) on center. Heating cables used for snow melt systems shall be installed in accordance with Section 1222.9.

**Exception:** Constant wattage heating cables intended for installation in concrete or poured masonry floors shall comply with Section 1222.2.4.

1222.2.1 Plastered Ceilings. The cables shall be secured to a fire-resistant material. Electrically conductive surfaces shall be isolated from the cable with a coat of plaster. The surface shall be finished with a noninsulating plaster and applied in accordance with the manufacturer’s installation instructions.

1222.2.2 Gypsum Ceilings. In gypsum ceilings, the heating cable runs shall be parallel to the joist with 2\(\frac{1}{2}\) inches (64 mm) of clearance between centers of adjacent runs of cable.

1222.2.3 Laminted Ceiling Panels. For gypsum laminated ceiling panels, the heating cables shall be installed between two layers of fire-resistant material, such as gypsum. The cable shall be secured to the upper lath. The cable shall be permitted to be held together by the two layers of lath, where the two layers are separated by the thickness of the cable, and the space between the two layers of lath is filled with a noninsulating plaster or similar material. The plaster shall be applied in accordance with the manufacturer’s installation instructions.

1222.2.4 Installation in Concrete or Poured Masonry. Electric space heating cables installed in concrete slabs shall be installed in one or two pours. For single-pour applications, the cable shall be secured, by an approved means, to the top of the reinforcing steel prior to the pour. For two pour applications, the cable shall be laid on top of the bottom slab and secured by an approved means prior to pour of the finish layer. The constant wattage heating cables shall not exceed 56.2 [(Btu/h)/ft] (0.054 kW/m) and shall be installed such that the spacing between adjacent runs is not less than 1 inch (25.4 mm) on centers.

1222.3 Heating Panels or Heating Panel Sets. Heating panels or heating panel sets that are designed to be permanently connected to a supply circuit, and that are intended to form an integral part of the building shall be listed for such use. The ceiling panels shall be secured in accordance with the manufacturer’s installation instructions. Where insulation is used, the junction box shall not be covered with the insulation. Heating panels or heating panel sets shall not exceed 112.6 British thermal units per hour per square foot [(Btu/h)/ft²] (0.355 kW/m²) where installed in concrete or poured masonry.

**Exception:** Heating panels or heating panel sets installed directly below floor coverings shall be installed in accordance with NFPA 70.

1222.4 Drop or Suspended Ceiling Panels. Panels used as a drop or suspended ceiling shall be designed for such use and shall be installed in accordance with the manufacturer’s installation instructions. The supports shall be securely fastened to the building structure and be capable of supporting the weight of the panel.

1222.5 Preformed Mats. Preformed mats shall be installed in accordance with the manufacturer’s installation instructions.

1222.6 Surface Temperature. The surface temperature shall not exceed the maximum temperature rating of the materials used in the construction of the electric radiant heating panel. The surface temperature of wall panels that are installed less than 6 feet (1829 mm) above the floor shall not exceed 140°F (60°C). The heating panel or panel set shall be protected with a high-limit control.

1222.7 Protection. Electric space heating cables shall be protected from nail penetration by an approved means.

1222.8 Insulation. Thermal insulation for an electric radiant heating panel shall be installed in accordance with the manufacturer’s installation instructions. The thermal resistance \(R\) shall comply with Section 1217.6 through Section 1217.6.4. Where the insulation is installed in a thermal mass, the insulation used shall be capable of supporting the expected stresses in load bearing surfaces such as driveways.

1222.9 Snow Melt. Electric heating cables installed in concrete shall be designed for such installation and shall be installed such that they do not overlap and shall be installed in accordance with the manufacturer’s installation instructions.

Where embedded in a concrete slab, the top of the cables or elements shall be embedded in the slab not less than 1\(\frac{1}{2}\) inches (38 mm) and not more than 2\(\frac{1}{2}\) inches (64 mm) below the surface. Electric heating cables shall be supported to maintain the desired spacing and depth during the pour.

Where installed under asphalt, the cables or elements shall be embedded in a compacted sand or gravel not less than \(\frac{1}{2}\) of an inch (12.7 mm) of cover. Heating cables installed in asphalt shall be installed in accordance with the manufacturer’s installation instructions.

**SUBSTANTIATION:**

1. Section 1217.7.1 has been revised to expand on the provisions for electric heating panels by adding Section 1222.0 through Section 1222.9 as, currently, the code does not address specific provisions pertaining to elec-
trical radiant heating and cooling panels. Electric radiant heating is a commonly used method for heat transfer. All of the proposed provisions are consistent with current industry practice and NFPA 70. All requirements are consistent with NFPA 70 (Article 424) and ASHRAE Handbook (2012).

2. In Section 1222.2 (Electric Heating Cables), minimum installation requirements are being added for space heating cables intended to be installed in ceilings, within, or beneath floors of enclosed structures where the floor is constructed of noncombustible material, concrete, or asphalt.

3. In Section 1222.2.1, minimum installation requirements for heating cables installed in plaster ceiling are being added which are consistent with industry standards.

4. In Section 1222.2.2, minimum installation requirements electric heating cables installed in gypsum ceilings are being added which are consistent with industry standards.

5. In Section 1222.2.3, it is essential that the space between the two layers of lath be completely filled with a non-insulating plaster or similar material. This fill holds the cable firmly in place and improves heat transfer between the cable and the finished ceiling. Failure to completely fill the space between the two layers of plasterboard may allow the cable to overheat in the resulting voids, and may cause cable failure. The plaster should be applied according to the manufacturer’s instructions.

6. Section 1222.2.4 will address provisions for electric heating cables in a poured system as it is common practice in the industry. The pouring required for these systems can be done either in a single pour or in two pours. Regardless, of the pouring system that is utilized it is crucial that the cables are held in place during the pours so that the spacing can be maintained.

7. In Section 1222.3, requirements are being added to address radiant heating panels and heating panel sets that are permanently connected to a supply circuit, and intended to form an integral part of the building construction.

8. In Section 1222.4, provisions for panels used in drop or suspended ceilings are being added which are consistent with industry practice.

9. Section 1222.5 will address provisions for mats being used as a method for space heating. Preformed mats are sometimes used for electric slab heating systems. These mats usually consist of PVC-insulating heating cable woven into or attached to metallic or glass fiber mesh, which are installed in accordance with the manufacturer’s installation instructions.

10. Section 1222.6 will address the minimum requirements for floor surface temperatures. The 140°F will protect the public from hot surfaces, which is consistent with Chapter 6 (Ducts) and the UPC.

11. Section 1222.7 will address the protection of electric panels installed in concealed locations. Such installations should be approved by the Authority Having Jurisdictions, and be protected from nail penetrations as it can cause damage to the system.

12. Section 1222.8 will require insulation to be installed in accordance with the manufacturer’s installation instructions, and the thermal resistance to comply with Section 1217.6 through Section 1217.6.4. Furthermore, the insulation shall be capable of supporting stresses, such as vehicles, without any damage.

13. Section 1222.9 will address snow melt systems as the code is silent on the safe installation of heating cables used for snow melt applications. The distances provided are consistent with current industry standards. If the concrete slab is too thin, then the surface can reach a temperature that can pose a danger to the public. If the concrete is too thick, then there won’t be enough heat transfer to perform its function.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The proposed language would introduce a concept that has not had a public review by being included in a related proposal as published in the ROP. Furthermore, electric radiant heating is out of the scope of the UMC.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza
EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• Section 1217.7.1 should be deleted. This chapter is about hydronic systems. Electrical systems are not in the scope.
• In Section 1217.7.2, “high moisture areas” is not well enough defined to be enforceable.

PUBLIC COMMENT 2:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee
RECOMMENDATION: Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of radiant heating and cooling panels. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The sections should be revised as follows:
1217.7 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.
1217.7.1 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.
1217.7.21 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 expansion screws of sufficient size and anchorage to support the loads applied. In high moisture areas, 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.

Rationale
• Section 1217.7.1 should be deleted. This chapter is about hydronic systems. Electrical systems are not in the scope.
• In Section 1217.7.2, “high moisture areas” is not well enough defined to be enforceable.
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.

SUBSTANTIATION:
The system must have adequate protection to ensure that the potability of the water supply and distribution system is properly safeguarded. The type of heat exchanger (single or double wall) depends on the type of heat transfer fluid. For the use of a single wall heat exchanger, the heat transfer medium must be potable water or classified as food grade and safe by the FDA. Systems that do not comply with the requirements for a single wall heat exchanger must install a double-wall heat exchanger. The double-wall heat exchanger must have an intermediate space between the walls that is open to the atmosphere. This type of construction would allow any leakage of fluid through the walls of the heat exchanger to discharge externally to the heat exchanger where it would be observable.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort
is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

**COMMITTEE ACTION:** Reject the public comment

**COMMITTEE STATEMENT:**
The public comment removes provisions that are necessary for the enforcement of heat exchangers. Furthermore, there was no technical substantiation provided to warrant the change.

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  
**AFFIRMATIVE:** 20  
**NEGATIVE:** 1  
**NOT RETURNED:** 1 Garza

**EXPLANATION OF NEGATIVE:**
**TAYLOR:** This is already covered in the plumbing code which is where it belongs. The UMC is about mechanical systems not plumbing systems. Note that the UPC language for this issue is almost the same but no exactly so having this here creates a conflict.
SUBMITTER: Phil Ribbs
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 19)

RECOMMENDATION:
Add new text as follows:

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.

SUBSTANTIATION:
Where a system has a dual purpose water heater that supplies hot water and serves as a heat source for a hot water space heating system, the maximum outlet water temperature for the potable hot water distribution system is limited to 140°F (60°C). A master thermostatic mixing valve conforming to ASSE 1017 must be installed to limit the water temperature to 140°F (60°C) or less. These valves are used extensively in applications for domestic service to mix hot and cold water to reduce high service water temperature to the building distribution system. These devices are not intended for final temperature control at fixtures and appliances. A water heater used as part of a space heating system must be protected from any conditions that can cause contamination of the potable water supply system. A typical installation might be an under-floor radiant heating system. Because the water heater is part of the potable water system, materials used in the heating system must be approved for use in a potable water system, and all connections must be protected against contamination.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.
COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of hot water storage tanks. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: I am voting negative for the following reasons:
• This is already covered in the plumbing code which is where it belongs. The UPC language for this issue is also much more detailed and complete.
• The second paragraph requires a mixing valve for control of DHW, but combined systems using a separate heat exchanger must be controlled with a control valve on the HHW side of the HX. This requirement is technically incorrect.
1220.0 Auxiliary Systems.

1220.1 General. Additional heating loads shall be sized in accordance with one of the following methods and the required additional capacity shall be added to the primary heat source:

1. Methods included in this chapter.
2. Other approved engineering methods acceptable to the Authority Having Jurisdiction.
3. Sizing guidelines included in the manufacturer’s instructions.

Where an auxiliary system is deemed to be in use only in seasons other than winter, it shall not be required to be combined with the space heating requirement in the winter. The heat source shall be sized to the level of the highest total seasonal load.

1220.2 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.

1220.3 Snow Melt. An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature, as specified in Section 1213.5. Snow melt auxiliary systems shall be protected from freezing with an approved hydronic solution. The circulating heat transfer fluid shall be a mixture of propylene or ethylene glycol and water. Automotive antifreeze shall not be used.

1220.3.1 Tube Placement. Snow melt tubing shall be installed in accordance with the manufacturer’s installation instructions and with the tubing layout and spacing as specified in the system design. Except for distribution mains, tube spacing that is shown in the design as center-to-center and the individual loop lengths shall be installed with a variance of not more than ±10 percent from the design.

The length of continuous tubing from a supply-and-return manifold arrangement shall not exceed the lengths specified by the manufacturer’s installation instructions and system design or, in the absence of manufacturer’s specifications, the lengths specified in Table 1220.3.1. Actual loop lengths shall be determined by spacing, flow rate, temperature, and pressure drop, as specified in the system design.

<table>
<thead>
<tr>
<th>TABLE 1220.3.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOOP LENGTHS FOR SNOW MELT SYSTEMS²⁸⁹¹²</td>
</tr>
<tr>
<td>SIZE (inches)</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>PEX Tubing</td>
</tr>
<tr>
<td>1/8</td>
</tr>
<tr>
<td>3/8</td>
</tr>
<tr>
<td>1/2</td>
</tr>
<tr>
<td>Copper Tubing¹</td>
</tr>
<tr>
<td>1/8</td>
</tr>
<tr>
<td>3/8</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm

Notes:
1. The total 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 Type K copper water tubing.
1220.3.2 Poured Concrete Slab Systems (Thermal Mass). Where tubes are embedded in a 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. The top of the tubing shall be embedded in the slab not less than 2 inches (51 mm) below the surface.

1220.3.3 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 a protective pipe sleeve. The space between the tubing and sleeve shall be sealed. The tubing at the location of a 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.

1220.3.4 Concrete Slab Preparation. A solid foundation shall be prepared before the tubing is installed. Compaction shall be used for slabs, sidewalks, and driveways.

1220.3.5 Insulation. Where a poured concrete snow melt system is installed in contact with the soil, insulation that has a R-5 value shall be placed between the concrete and the compacted grade; extend 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.

1220.3.6 Testing. Testing of auxiliary systems shall be in accordance with Section 1205.2.

1220.4 Hydronic Makeup Air Units. Hydronic makeup air units that are affected by freezing shall be protected against freezing by a hydronic solution or a method approved by the Authority Having Jurisdiction.

SUBSTANTIATION:
Auxiliary systems need to be addressed as additional loads are placed on the system along with chemical additives, corrosive fluids, or both. These recommended requirements address the design, installation and operation of snow and ice melting systems. The expected output should be based on the rate of snowfall, air dry-bulb temperature, humidity, wind speed, and dimension and design of controlled surfaces. The pipe spacing, pipe depth, and slab insulation can all have a significant effect on the heating capacity required to achieve a certain snow-melting performance. As can be seen, either increasing the pipe spacing or eliminating the bottom-side insulation degrades the performance of the system. Increasing the pipe spacing makes it more difficult to uniformly heat the top surface of the slab. However, increasing the pipe spacing requires higher fluid temperatures, some of which are infeasible. Preheating the slab with full heating capacity before snowfall can significantly improve the snow melting performance; however, it may result in excessively high fluid temperatures in mild weather conditions. These high fluid temperatures may not be achievable with typical system design constraints.

COMMITTEE ACTION: Accept as Amended by the TC
Amend proposal as follows:

<table>
<thead>
<tr>
<th>TABLE 1220.3.1</th>
<th>LOOP LENGTHS FOR SNOW MELT SYSTEMS$^{1,2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE (inches)</td>
<td>AVERAGE ACTIVE LOOP (feet)</td>
</tr>
<tr>
<td>PE-RT and PEX Tubing</td>
<td></td>
</tr>
<tr>
<td>5⁄8</td>
<td>225</td>
</tr>
<tr>
<td>3⁄4</td>
<td>300</td>
</tr>
<tr>
<td>1</td>
<td>450</td>
</tr>
<tr>
<td>Copper Tubing$^3$</td>
<td></td>
</tr>
<tr>
<td>½</td>
<td>–</td>
</tr>
<tr>
<td>¾</td>
<td>–</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm

Notes:
(1) The total PE-RT and PEX loop lengths consist of two separate sections, the active loop and the leader length. The active loop is installed within the heated slab. The leader length is the total distance to and from the manifold and heated slab, including any vertical distances.
(2) The manifolds shall be installed as close to the snow melt area as possible.
(3) In concrete use minimum Type L copper water tubing. In bituminous pavement use Type K copper water tubing.
COMMITTEE STATEMENT:
PE-RT is being added to Table 1220.3.1 as it is an acceptable material for snow melt applications.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of auxiliary systems. Furthermore, there was no technical substantiation provided to warrant the change.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The sections should be revised as follows:
1220.0 Auxiliary Systems Snow Melt Systems.
1220.1 General. Additional heating loads shall be sized in accordance with one of the following methods and the required additional capacity shall be added to the primary heat source.
(1) Methods included in this chapter.
(2) Other approved engineering methods acceptable to the Authority Having Jurisdiction.
(3) Sizing guidelines included in the manufacturer's instructions.
Where an auxiliary system is deemed to be in use only in seasons other than winter, it shall not be required to be combined with the space heating requirement in the winter. The heat source shall be sized to the level of the highest total seasonal load.
1220.2 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.
1220.13 Snow Melt Freeze Protection. An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature, as specified in Section 1213.5. Snow melt auxiliary systems shall be protected from freezing with an approved hydronic solution. The circulating heat transfer fluid shall be a mixture of propylene or ethylene glycol and water. Automotive antifreeze shall not be used.
1220.23 Tube Placement. Snow melt tubing shall be installed in accordance with the manufacturer's installation instructions and with the tubing layout and spacing as specified in the system design. Except for distribution mains,
tube spacing that is shown in the design as center to center and the individual loop lengths shall be installed with a variance of not more than ±10 percent from the design. The length of continuous tubing from a supply-and-return manifold arrangement shall not exceed the lengths specified by the manufacturer’s installation instructions and system design or, in the absence of manufacturer’s specifications, the lengths specified in Table 1220.3.12. Actual loop lengths shall be determined by spacing, flow rate, temperature, and pressure drop, as specified in the system design.

<table>
<thead>
<tr>
<th>SIZE (inches)</th>
<th>AVERAGE ACTIVE LOOP (feet)</th>
<th>TOTAL LOOP (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE-RT and PEX Tubing</td>
<td>225</td>
<td>250</td>
</tr>
<tr>
<td>¼</td>
<td>300</td>
<td>325</td>
</tr>
<tr>
<td>⅓</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>Copper Tubing</td>
<td>450</td>
<td>475</td>
</tr>
<tr>
<td>⅓</td>
<td>140</td>
<td>280</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm

Notes:
1. The total PE-RT and PEX loop lengths consist of two separate sections, the active loop and the leader length. The active loop is installed within the heated slab. The leader length is the total distance to and from the manifold and heated slab, including any vertical distances.
2. The manifolds shall be installed as close to the snow melt area as possible.
3. In concrete use minimum Type L copper water tubing. In bituminous pavement use Type K copper water tubing.

1220.3.2 Poured Concrete Slab Systems (Thermal Mass). Where tubes are embedded in a 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 (3 m) of the distribution manifold. The top of the tubing shall be embedded in the slab not less than 2 1/2 inches (38.0 mm) below the surface unless approved by the tubing manufacturer, concrete floor designer, and Authority Having Jurisdiction.

1220.4.3 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 a protective pipe sleeve. The space between the tubing and sleeve shall be sealed. 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 expansion joint or the tubing shall be installed below the slab.

1220.5.4 Concrete Slab Preparation. A solid foundation shall be prepared before the tubing is installed. Compaction shall be used for slabs, sidewalks, and driveways.

1220.6.5 Insulation. Where a poured concrete snow melt system is installed in contact with the soil, insulation that has a R5 value shall be placed between the concrete and the compacted grade; extend 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.

1220.7.6 Testing and Flushing. Testing and flushing of auxiliary systems shall be in accordance with Section 1205.2.

1220.4 Hydronic Makeup Air Units. Hydronic makeup air units that are affected by freezing shall be protected against freezing by a hydronic solution or a method approved by the Authority Having Jurisdiction.

Rationale:
- Once the non-substantive sections are removed, this section is only about snow melting. So the title is changed accordingly.
- Section 1220.1 says nothing substantive.
- Section 1220.2 (protecting domestic water systems) is addressed well in the plumbing code. If the intent is to separate systems with glycol and those without, double wall heat exchangers shall be provided.
• The freeze protection section is made to be not so prescriptive. There are various freeze protection approaches and additives.
• It is not possible to maintain the tube spacing listed right at the manifold.
• It goes without saying that systems that might freeze must be protected but using additives is not the only solution. Pumped coils are also popular. AHJ approval should not be needed.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 326 and USEHC Item # 052 resulted in a conflict within this code in regards to “snow melt.” In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

1220.3 Snow Melt. An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature, as specified in Section 1213.5. Snow melt auxiliary systems shall be protected from freezing with an approved hydronic solution. The circulating heat transfer fluid shall be a mixture of propylene glycol or ethylene glycol, and water. Automotive antifreeze shall not be used.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revision to Section 1220.3 of the UMC will correlate with the actions taken by the USEHC TC to “accept as modified” Item # 052.

The Committee statement provided by the USEHC TC for accepting Item # 052 as modified is as follows:
“The modification adds “glycol” as it clarifies that propylene glycol and water is a permitted mixture that can be used as a heat transfer fluid.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken on Section 1220.3 in regards to snow melt systems.
SUBMITTER:  Phil Ribbs  
Chair, UMC Code Review Task Group (see Code Review Task Group Report I Item # 21)

RECOMMENDATION:
Revise text as follows:

1221.0 Piping Installation.
1221.1 General. Piping, fittings, and connections shall be installed in accordance with the conditions of their approval.
1221.2 Embedded Piping and Joints. Piping for heating or cooling panels 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 plaster shall be installed in accordance with the requirements of Section 1221.2.1 through Section 1221.2.3.

1201.3.8.2 Piping Embedded in Structure. Piping shall not be built into or embedded in concrete or masonry, except where used for radiant panel heating or cooling. Black steel pipe, wrought-iron piping, or Type L copper tubing shall be permitted to be embedded.

1201.3.8.5(A) Beneath Buildings. Piping located within a building and in, or under, a concrete floor slab resting on the ground shall be installed as follows:
(1) Ferrous piping shall be galvanized and covered with an approved protective coating.
(2) Copper tubing shall be installed without joints.
(3) Asbestos-cement pipe shall not be installed beneath a building.

1201.3.8.5(B) Outside of Buildings. Underground piping located outside of buildings shall be installed as follows:
(1) Black wrought iron and black steel piping shall be protected against corrosion by an approved pipe wrapping.
(2) Asbestos-cement piping shall be installed in accordance with the manufacturer’s installation instructions, but shall not be installed within 2 feet (610 mm) of a building.

1205.0 Piping Joints.
1205.1 General. Joints of pipe or tubing forming the panel that are embedded in a portion of the building, for example, concrete or plaster, shall be in accordance with the following:
(1) Steel pipe welded with electrical arc or oxygen/acetylene method.
(2) Copper tubing joined with brazing alloys having a melting point above 1000°F (538°C).

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 Tested. Piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During the pour, the pipe shall maintain the test pressure of not less than one and one-half times the operating pressure but 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.

1203.2 Pressure Testing. 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.

1204.0 Piping Materials.
1204.1 Panel(s). Piping for heating panels shall be standard weight steel pipe, Type L copper tubing, or approved plastic pipe or tubing rated at 100 pounds-force per square inch (psi) (689 kPa) at 180°F (82°C).
1204.2 Hot Water Supply Lines. Piping for hot water supply lines shall be installed in accordance with the requirements in Chapter 10.
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 1017.1. 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 312.0.

1201.3.8.6 (G) Drainage. Means shall be provided to drain all piping.

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.

SUBSTANTIATION:
The proposed language provides clear and concise provisions for the installation of piping including joining methods for materials embedded in concrete. To facilitate system repairs and maintenance, hydronic piping systems must be sloped and arranged to allow the transfer-medium fluids or condensate to be drained from the system. Each trapped section of the system piping must have drain cocks, unions or some other means of opening the system to drain it. Drainage discharge to the plumbing system must be by an indirect connection.

Maintaining a 1-inch clearance allows some of the heat energy from the hydronic pipe to dissipate before reaching adjacent combustible materials. Continuous exposure to the heat produced by hydronic piping can chemically alter adjacent combustible materials, thereby lowering the ignition temperature and creating a potential fire hazard. Except for steam applications, temperatures near 250°F are not typically found in hydronic systems. Even if the design temperature is less than 250°F, a clearance to combustibles should be maintained when higher temperatures are possible or when the maximum set point of system limit controls exceeds 250°F.

Testing of piping is necessary to disclose any defects in the system. This testing is especially important where the piping is to be encased and thereby made inaccessible.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steven T. Taylor, P.E., Taylor Engineering LLC/Rep. ASHRAE liaison to the UMC Technical Committee

RECOMMENDATION:
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:
The changes proposed to Chapter 12, in Items # 305 through # 315 and Items # 317 through # 327, completely rewrite the chapter in a somewhat random way. It is not well organized, in some cases redundant, inadvertently eliminates some existing requirements, and has several errors. While I agree that Chapter 12 needs work, this effort is at least partly a step backwards and will require significant changes, which will confuse users of the model code. I urge the Committee to start over with a clean slate and take the time needed to do this right. It should be clear that major changes are needed.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
The public comment removes provisions that are necessary for the enforcement of piping installations. Furthermore, there was no technical substantiation provided to warrant the change.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: The section should be revised as follows:

1221.0 Piping Installation.

1221.1 General. Piping, fittings, and connections shall be installed in accordance with the conditions of their approval.

1221.20 Embedded Piping and Joints.

1221.1 Materials. Piping for heating or cooling panels 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 plaster 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.

1221.35 Pressure Tested Testing. Piping to be embedded in concrete shall be pressure tested in accordance with Section 1205.1 prior to pouring concrete. During the pour, the pipe shall maintain the test pressure, of not less than one and one half times the operating pressure but 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 1017.1. 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 312.0.

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.

Rationale:
- Having an “Installation” section here is not logical given the several previous sections that are also about installation. It is primarily addressing in-slab piping so the section should focus on that.
- There is no reason to repeat requirements for joints so this reference is deleted.
- The pressure testing section is simplified by referencing Section 1205.1.
- The system drainage section is not clear. If it means that all low points in a system need to be piped to a drain, it is way too stringent. That would prevent offsets in piping unless drains were added. Even adding drains with hose bibs at all low points is overly expensive. Buildings have managed to survive without this requirement for years so there is no compelling reason to add this requirement.
- Condensate piping is already addressed in Chapter 3 including sloping requirements.
- Fire safety requirements with respect to hot surfaces are already addressed in the building code.
- Note that the deletions included in this item include underground piping which then would no longer be addressed. This may be one of the inadvertent changes made in this wholesale change to the code.
Item # 333

UMC 2015 – (1301.3, 1308.5.3.4, 1308.5.10.1, 1308.5.10.4, 1308.5.11.2, 1308.5.11.3, 1308.7, 1308.7.2, 1308.7.5.1, 1308.7.5.3, 1308.7.5.4, 1308.8, 1310.1, 1311.1.1, 1311.1.6, 1311.1.6.1, 1311.1.7.2, 1311.5, 1311.8.1, 1311.8.1.1, 1311.10.1.1, 1311.14.4, 1312.4, 1312.5, 1314.0, 1314.1, 1316.4, 1316.8.4):

SUBMITTER: Dave Levanger

RECOMMENDATION:
Revise text as follows:

1301.3 Applications. This code shall not apply to the following (reference standards for some of which appear in Chapter 17):

(1) Portable LP-Gas appliances and equipment that are not connected to a fixed fuel piping system.
(2) - (4) (remaining text unchanged)
(5) Industrial gas applications using such gases as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen, and nitrogen.
(6) - (11) (remaining text unchanged)
(12) LP-Gas equipment for vaporization, gas mixing, and gas manufacturing.
(13) - (14) (remaining text unchanged)
(15) Installation of LP-Gas and compressed natural gas (CNG) systems on vehicles.
(16) (remaining text unchanged)

1308.5.3.4 Corrugated Stainless Steel. Corrugated stainless steel tubing shall be tested and listed in accordance with the construction, installation, and performance requirements of CSA LC-1. [NFPA 54:5.6.3.4]

1308.5.10.1 Pipe Joints. Pipe joints shall be threaded, flanged, brazed, press connected, or welded. 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. [NFPA 54:5.6.8.1]

1308.5.10.4 Metallic Pipe Fittings (Including Valves, Strainers, Filters). Metallic pipe fittings shall comply with the following:

(1) - (4) (remaining text unchanged)
(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) - (7) (remaining text unchanged)
(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. [NFPA 54:5.6.8.4]
1308.5.11.2 Heat-Fusion Joint. Heat-fusion joints shall be made in accordance with AWS D2.4 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)]

1308.5.11.3 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 pipe or tubing, and shall extend not less than to 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)]

1308.7 Gas Pressure Regulators. A line gas pressure regulator or gas appliance pressure regulator, as applicable, shall be installed where the gas supply pressure exceeds that at which the branch supply line or appliances are designed to operate or vary beyond design pressure limits. [NFPA 54-12:5.8.1]

1308.7.2 Listing. Line gas pressure regulators shall be listed in accordance with CSA Z21.80. [NFPA 54:5.8.2]

1308.7.5.1 Line Gas Pressure Regulators. Line gas pressure regulators shall be installed and designed in accordance with the following requirements:

(remaining text unchanged)

1308.7.5.3 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 into 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 not less than the same size as the outlet of the pressure-relieving device. [NFPA 54:5.9.7]

1308.7.5.4 Discharge of Vents. The discharge of vents shall be installed and designed in accordance with the following:

(1) The discharge stacks, vents, or outlet parts of pressure-relieving and pressure-limiting devices shall be located so that gas is safely discharged into 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 not less than the same size as the outlet of the pressure-relieving device. [NFPA 54:5.9.7]

1308.8 Backpressure Protection. Protective devices shall be installed as close to the appliance equipment as practical where the design of the appliance 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]

1310.1 General. Venting of gas appliance pressure regulators shall be in accordance 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, where 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) - (5) (remaining text unchanged)

(6) Vent lines from an gas appliance pressure regulator and bleed lines 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 54:9.1.19]

1311.1.1 Cover Requirements. Underground piping systems shall be installed with a cover not less than 182 inches (457 mm). Where external damage to the pipe or tubing from external forces is not likely to result, the cover shall be not less than 128 inches (325 mm). Where a cover not less than 12 inches (305 mm) cannot be provided, the pipe shall be installed in conduit or bridged (shielded). [NFPA 54:7.1.2.1]
1311.1.6 Piping Underground Beneath Buildings. Where gas piping is installed underground beneath buildings, the piping shall be either one of the following:

(remaining text unchanged)

1311.1.6.1 Conduit with One End Terminating Outdoors. The conduit shall extend into an normally usable and 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 a gas leakage. Where the end sealing is of a type that will retain the full pressure of the pipe, the conduit shall be designed for the same pressure as the pipe. The conduit shall extend not less than 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]

1311.1.7.2 Tracer Wire. 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 of the tracer wire or tape shall be brought aboveground at a building wall or riser. [NFPA 54:7.1.7.3]

1311.5 Maximum Design Operating Pressure. The maximum design operating pressure for piping systems located inside buildings shall not exceed 5 psi (34 kPa) unless one or more of the following conditions are met: [NFPA 54:5.5.1]

1. The piping system is welded. [NFPA 54:5.5.1(1)]
2. The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation. [NFPA 54:5.5.1(2)]
3. 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 equipment rooms [NFPA 54:5.5.1(3)]
4. The piping is a temporary installation for building under construction. [NFPA 54:5.5.1(4)]
5. The piping serves appliances or equipment used for agricultural purposes. [NFPA 54:5.5.1(5)]
6. The piping system is an LP-Gas piping system with a design operating pressure exceeding 20 psi (138 kPa) and designed in accordance with NFPA 58. [NFPA 54:5.5.2]

1311.8.1 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. Where an appliance or equipment is disconnected from an outlet, and the outlet is not to be used again immediately, it shall be closed capped or plugged gastight. Exceptions:

1. Laboratory equipment appliances installed in accordance with Section 1312.2.1 shall be permitted.
2. (remaining text unchanged)

1311.8.1.1 Appliance Shutoff Valves. Equipment 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]

1311.10.1.1 Shutoff Valves for Multiple House Lines. In multiple-tenant buildings supplied through a master meter, or 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 54:7.9.2.2]

1311.14.4 Lightning 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]
1312.4 Appliance Shutoff Valves and Connections. Appliances 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 and shall be installed 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 gas appliances shall be permitted to be installed in fireplaces where listed for such use. [NFPA 54:9.6.4, 9.6.4.1]

1312.5 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 54:9.6.5]

1314.0 Safety Shutoff Devices for Unlisted LP-Gas Appliance Used Indoors.
1314.1 General. Unlisted gas utilization appliances for use with undiluted liquefied petroleum 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]

1316.4 New Branches. Where new branches are installed from the point of delivery to new appliances, the newly installed branches 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]

1316.8.4 Designed for (less than) Operating Pressures. Where the piping system is connected to appliances, equipment, or equipment components designed for operating pressures of less than the test pressure, such appliances, equipment, or equipment components shall be isolated from the piping system by disconnecting them and capping the outlets. [NFPA 54:8.1.3.4]

SUBSTANTIATION:
1. Sections 1301.3, 1308.5.3.4, 1308.5.10.1, 1308.5.10.4, 1308.5.11.3, 1308.7, 1308.7.2, 1308.7.5.1, 1308.7.5.4, 1308.8, 1310.1, 1311.1.1, 1311.1.6, 1311.1.6.1, 1311.1.7.2, 1311.5, 1311.8.1, 1311.8.1.1, 1311.10.1.1, 1311.14.4, 1312.4, 1312.5, 1314.1, 1316.4, and 1316.8.4 are being revised to correlate with NFPA 54-2012.
2. Section 1308.5.11.2 is being revised to correlate with NFPA 54-2012. The standard AWS B2.4 is being deleted as this standard is not in the extraction and does not pertain to heat-fusion or welding of joints, it pertains to the qualifications of the welder.
3. Section 1308.7.5.3 is being deleted as this information is duplicated in Section 1308.7.5.4

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Curtis Dady, Viega, LLC

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

1308.5.10.1 Pipe Joints. Pipe joints shall be threaded, flanged, brazed, or welded, or made by press-connect fittings 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. [NFPA 54:5.6.8.1]

SUBSTANTIATION:
Table 1701.1 lists “CSA LC4-2007 (Press-Connect Copper and Copper Alloy Fittings for Use in Fuel Gas Distribution Systems) (Same as CSA 6.3.2).” Furthermore, CSA LC4 is referenced in Section 1308.5.10.2 (Tubing Joints). The scope (Section 1.1) of CSA LC4 has been revised to include steel and stainless steel materials, as well as pipe
and tubing joint connections. Because of the change of scope, the new title of the CSA LC4 standard is now “Press-Connect Metallic Fittings for use in Fuel Gas Distribution Systems,” and has been proposed for inclusion into Table 1701.1. Therefore, Section 1308.5.10.1 should be revised to include the text “press-connected fittings” to harmonize with the title change of the standard, Table 1701.1, and Section 1308.5.10.2.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT: The accepted comment creates a conflict between two ANSI Standards, the National Fuel Gas Code (NFPA 54/Z223.1) and the UMC by revising an extracted section from NFPA 54/Z223.1. Conflicts between ANSI Standard must be avoided.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 333 and UPC Item # 301 resulted in a conflict within this code in regards to “pipe joints.” In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

1308.5.10.1 Pipe Joints. Pipe joints shall be threaded, flanged, brazed, welded, or made by 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.

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revision to Section 1308.5.10.1 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 301.

The Committee statement provided by the UPC TC for accepting Item # 301 as amended is as follows: “The proposed modification will clarify the intent of the section in regards to press-connect fittings for pipe joints.”

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken Section 1308.5.10.1 in regards to pipe joints.
Item # 335  
UMC 2015 – (1308.5.4, Table 1701.0):

SUBMITTER: Denise Beach  
National Fire Protection Association (NFPA)

RECOMMENDATION:  
Revise text as follows:

1308.5.4 Plastic Pipe, Tubing, and Fittings. Polyethylene plastic pipe, tubing, and fittings used to supply fuel gas shall be in accordance with ASTM D2513. Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009. Pipe to be used shall be marked “gas” and “ASTM D2513.” [NFPA 54, 5.6.4.1.1, 5.6.4.1.2]

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Note: ASTM D2513 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects

(subststiation)

RECOMMENDATION:  
Request to reject the code change proposal by this public comment.

SUBSTANTIATION:  
The end user always has the option to use an alternative material in accordance with Section 302.2; therefore, such language is not required. Furthermore, the language will create confusion as the code will be required to list two editions of ASTM D2513 in Table 1701.0.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:  
The scope of the 2009 edition of ASTM D2513 was modified to include only polyethylene piping. Polyamide piping has been used successfully as fuel gas piping for many years. Polyamide piping should conform to the 2009 edition of ASTM D2513 until such time that ASTM publishes a new standard on polyamide piping for fuel gas applications.
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20 NEGATIVE: 1 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
ADLER: I disagree with the rejection of this public comment that was submitted by Dave Mann. The code change proposal should be rejected as I agree with Dave’s substantiation.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 335 and UPC Item # 301 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

1308.5.4 Plastic Pipe, Tubing, and Fittings. Polyethylene plastic pipe, tubing, and fittings used to supply fuel gas shall be in accordance with ASTM D2513. Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009. Pipe to be used shall be marked “gas” and “ASTM D2513.” [NFPA 54-12:5.6.4.1.1, 5.6.4.1.2]

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<td>STANDARD NUMBER</td>
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<td>ASTM D2513</td>
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</table>

(Portions of table not shown remain unchanged)

TCC COMMITTEE ACTION: Accept as Submitted

TCC COMMITTEE STATEMENT:
The revision to Section 1308.5.4 of the UMC will correlate with Section 1208.5.4 in regards to plastic pipe, tubing, and fittings. The language “Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009” was added to Section 1308.5.4 of the UMC in Item # 335. However, the language does not correlate with the UPC. Therefore, it should be removed to correlate with similar Section 1208.5.4 of the UPC.

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC for action taken Section 1308.5.4 in regards to plastic, pipe, tubing, and fittings.
1312.4.1 Vented Fireplaces and Vented Firebox. Shutoff valves serving appliances installed in vented fireplaces and ventless firebox enclosures shall not be required to be located within 6 feet (1829 mm) of the appliance where such valves are readily accessible and permanently identified. The piping from the shutoff valve to within 6 feet (1829 mm) of the appliance shall be designed, sized, installed, and tested in accordance with the applicable requirements in this chapter. [NFPA 54:9.6.4.2]

1312.4.2 Manifold. Where installed at a manifold, the appliance shutoff valve shall be located within 50 feet (15 240 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 the applicable requirements in this chapter. [NFPA 54:9.6.4.3]

SUBSTANTIATION:
The appliance shutoff valve is not an emergency valve. It is required so that the appliance can be maintained or replaced without shutting off the entire system. The existing 6 ft minimum distance has been in codes for many decades and is an arbitrary distance. Manual shutoff valves are installed to permit the servicing of individual gas equipment without the need to shut down the entire system. Therefore, the remote installation of equipment shutoff valves serving individual appliances should be allowed if they are readily accessible and identified. The proposed revisions provide safe and reasonable installation requirements for shutoff valves that are only used when servicing or replacing the equipment. There is little safety need for these valves to be located within 6 feet of a gas log or gas fireplace or when a manifold piping system is installed.

The concept of a central appliance shutoff location is similar to the philosophy of electricity distribution in buildings, with all switches (shutoffs) located in one place. There is no technical reason to not allow this, and the experience in Canada where it has been allowed for many years, and in the areas where NFPA 54 is adopted demonstrates that it is safe. The language would not mandate manifolding appliance shutoffs at a central location, but would permit it as an option for installers.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
In Section 1312.4.2, the 50 feet distance between the shutoff valve and the appliance does not provide an acceptable level of safety.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: James Ranfone, American Gas Association (AGA)

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

SUBSTANTIATION:
The Committee rejected the proposed change without technical justification. The requirements are extracted from the National Fuel Gas Code (ANSI Z223.1/NFPA 54-2012). The change would harmonize the requirements in the
UMC with those of ANSI Z223.1/NFPA 54. The language would not mandate the manifolding of an appliance shut-off at a central location, but would be permitted as an option for installers.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT:
In Section 1312.4.2, the 50 feet distance between the shutoff valve and the appliance does not provide an acceptable level of safety.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 19 NEGATIVE: 2 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT, TAYLOR: The failure of the committee to accept the comment keeps in place a conflict between two ANSI Standards, NFPA 54/Z223.1 and the UMC. Conflicts between ANSI standards must be avoided. The committee provides no technical reason to disallow the alternate shutoff valve locations.
1316.9 Test Pressure. This inspection shall include an air, CO$_2$, 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. These tests shall be made in the presence of the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder. Test pressure shall be measured with a manometer or with a pressure measuring device designed and calibrated to read, record, or indicate a pressure loss due to leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not more than 5 times the test pressure. The test pressure to be used shall be not less than one and one-half times the proposed maximum working pressure, but not less than 3 pounds-force per square inch (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 more than 50 percent of the specified minimum yield strength of the pipe. [NFPA 54: 8.1.4.1, 8.1.4.2]

1316.9.1 Test Duration. Test duration shall be not less than $\frac{1}{2}$ hour for each 500 cubic feet (14.16 m$^3$) of pipe volume or fraction thereof. Where testing a system having a volume less than 10 cubic feet (0.28 m$^3$) or a system in a single-family dwelling, the test duration shall be not less than 10 minutes. The duration of the test shall not be required to exceed 24 hours. [NFPA 54: 8.1.4.3]

SUBSTANTIATION:
In the 2012 revision cycle, no evidence was provided to the committee that the test pressures codified in NFPA 54, National Fuel Gas Code are inadequate. No evidence was provided that the revised higher pressure tests minimums provide increased safety. The text 2012 edition text establishes two new arbitrary minimum test pressures in direct conflict with the American National Standard NFPA 54 /Z223.1, National Fuel Gas Code and also the ASME pressure piping standards: B31.1 Power Piping and B31.3 Process Piping. The test pressures shown above were adopted into the 2000 edition of the UMC and were successfully utilized for over 10 years prior to the 2012 edition.

COMMITTEE ACTION: Reject

COMMITTEE STATEMENT:
The committee prefers the existing language which provides an acceptable method of test pressure.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT 1:
SUBMITTER: James Ranfone, American Gas Association (AGA)

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

SUBSTANTIATION:
The Committee rejected the proposed change without technical justification. The UMC pressure requirements conflict with the National Fuel Gas Code (ANSI Z223.1/NFPA 54-2012). No technical justification was provided for this change.
change during the 2012 revision cycle. The UMC requires all gas piping systems operating above 14 inches water column (½ psi) to be tested at 60 psig. This pressure is excessive and may stress certain gas piping systems. Excessive test pressures will increase the potential for worker injuries during testing.

COMMITTEE ACTION: Reject the public comment

COMMITTEE STATEMENT: The public comment removes provisions which provides an acceptable method for pressure testing.

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 18 NEGATIVE: 3 NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
CABOT: The failure of the committee to accept the comment keeps in place a conflict between two ANSI Standards, NFPA 54/Z223.1 and the UMC. Conflicts between ANSI standards must be avoided. The committee provides no technical reason to allow the long established pressure testing requirement from NFPA 54/Z223.1.

RAMOCIOTTI: The code change as presented would eliminate copper tubing as a material and/or it would cause confusion for the use of copper tubing since the section would apply to steel pipe only.

TAYLOR: Conflict is created with NFPA.

PUBLIC COMMENT 2:
SUBMITTER: Robert Torbin, Omega Flex, Inc.

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

1316.9 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 steel 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 not more than 30 psi (207 kPa) for 30 minutes. These tests shall be made in the presence of the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder.

SUBSTANTIATION: The 2012 UMC includes CSST as an acceptable gas piping material as stated in Section 1308.5.3.4, and in accordance with the CSA LC-1 Standard. CSA and IAPMO R&T certify CSST products based on this standard. The CSA LC-1 Standard limits the design pressure on CSST to 25 psi (performance requirements within the standard limit the test pressure to 37.5 psi). Therefore, requiring a pressure test at 60 psi would clearly violate the listing standard and the IAPMO certification, and in some cases can result in permanent deformation of the CSST. The use of 30 psi is considered a safe test pressure for CSST systems. Independent testing performed by Foster-Miller (Waltham, MA) has demonstrated the ability to detect any perforation/leak of the CSST wall (including a leak beneath the jacket) at test pressures between 3 psi and 10 psi.

COMMITTEE ACTION: Reject the public comment (Failed Ballot)
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 12 NEGATIVE: 9 NOT RETURNED: 1 Garza

Note: Item # 341 (Public Comment 2) failed to achieve the necessary 2/3 affirmative vote of returned ballots. In accordance with Section 4-4.6.4 of the Regulations Governing Committee Projects, the TC action shall be reported in the ROC as rejected.

EXPLANATION OF AFFIRMATIVE:

CABOT: While accepting this comment creates a conflict between two ANSI standard, NFPA 54/Z223.1 and the UMC, it addresses and mitigates a life safety concern regarding the maximum test pressures for CSST. To fully correct this issue, the Committee needs to accept Public Comment 1.

EXPLANATION OF NEGATIVE:

ADLER, BERGER, DIAS, MANN, RAMOCIOTTI: The code changes as presented would eliminate copper tubing as a material and/or cause for confusion for the use of copper tubing since the section would apply to steel pipe only

CAMPBELL: The comment should be rejected because it does not address all piping materials and therefore is incomplete and fails to give direction to installers and inspectors on testing for other materials.

CASEY: The language proposed by this comment seems to exclude otherwise approved material for gas piping (eliminates copper tubing) for higher pressure systems, implies only welded and steel piping systems would be approved. In addition, direction for pressure testing for CSST is vague.

FEEHAN: The language proposed by this comment eliminate copper tubing for higher pressure systems and implies only welded and steel piping systems would be approved.

RIBBS: First: The proposed code change will result in inconsistent code enforcement since it states CSST will be tested at a pressure of not more than 30 psi but there is no minimum pressure. Is 1,3,5,10,or 29 psi OK? Second: I believe the code change as presented will eliminate copper tubing and polyethylene as a gas piping material or at a minimum cause for confusion for the use of copper tubing or PE piping since the amended section would now only apply to steel pipe and CSST. Why is the minimum testing pressure requirement being lowered for a particular material when it is purported by the manufacturer that it is equal to steel, copper, and/or PE. All of these other materials have been tested successfully for decades at the current code requirements.
SUBMITTER: Luis Romeo Escobar  
Air Conditioning Contractors of America (ACCA)

RECOMMENDATION:
Revise text as follows:

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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the ACCA Manual J and Manual N standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Luis Romeo Escobar, Air Conditioning Contractors of America (ACCA)

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

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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the ACCA Manual Q and Manual QM standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Tim Orris, Air Movement and Control Association

RECOMMENDATION:
Revise text as follows:

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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revision reflects the latest update to the AMCA standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Tim Orris, Air Movement and Control Association

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

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<td>Louvers Impacted by Wind Borne Debris</td>
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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revision reflects the latest update to the AMCA standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21, NOT RETURNED: 1 Garza
SUBMITTER: Steve Ferguson  
The American Society of Heating Refrigerating and Air Conditioning Engineers

RECOMMENDATION:
Revise text as follows:

**TABLE 1701.0**  
**REFERENCED STANDARDS**

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<td>ASHRAE/ACCA 180-2008 2012*</td>
<td>Inspection and Maintenance of Commercial-Building HVAC Systems</td>
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<td>Cooling and Heating Load, Miscellaneous</td>
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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the ASHRAE standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steve Ferguson, The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

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

**TABLE 1701.0**  
**REFERENCED STANDARDS**

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<td>General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size</td>
<td>Cleaning Devices</td>
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<td>ASHRAE 55-2010 2015</td>
<td>Thermal Environmental Conditions for Human Occupancy</td>
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E 603.1.1 Temporary Ventilation During Construction. Temporary ventilation during construction shall be provided in accordance with the following:

1 - (3) (remaining text unchanged)

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, based on in accordance with ASHRAE 52.2, or an average efficiency of 30 percent based on in accordance with ASHRAE 52.1. 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 605.1.3.3 Infiltration Credit. Section E 605.1.3 includes a default credit for ventilation provided by infiltration of 2 ft³/min per 100 square feet [0.0001 (m³/s)/m²] of occupiable floor space. For buildings built prior to the application of this appendix, where excess infiltration has been measured using ASHRAE 136, the rates in Section E 605.1.3 shall be permitted to be decreased by half of the excess of the rate calculated from ASHRAE 136 that is above the default rate. [ASHRAE 52.2:4.1.3]

SUBSTANTIATION:
The above revisions reflect the latest updates to the ASHRAE standards that are referenced in Table 1701.0. Section E 603.1.1 and Section E 605.1.3.3 should be revised as the requirements from ASHRAE 52.1 have been incorporated into ASHRAE 52.2, and the requirements from ASHRAE 136 have been incorporated into ASHRAE 62.2.

COMMITTEE ACTION: Accept the public comment as submitted
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21    NOT RETURNED: 1 Garza
**RECOMMENDATION:**
Revise text as follows:

### TABLE 1701.0

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SUBSTANTIATION:
The above revisions reflect the latest updates to the ASTM standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Steve Mawn, American Society of Testing and Materials (ASTM)

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
### TABLE 1701.0
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(portions of table not shown remain unchanged)
SUBSTANTIATION:
The above revisions reflect the latest updates to the ASTM standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
**SUBMITTER:** Annette Alonso  
American Welding Society (AWS)

**RECOMMENDATION:**  
Revise text as follows:

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(portions of table not shown remain unchanged)

**SUBSTANTIATION:**

The above revisions reflect the latest updates to the AWS standards that are referenced in Table 1701.0.

**COMMITTEE ACTION:** Accept as Submitted

**A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**

**PUBLIC COMMENT:**

**SUBMITTER:** Angel Guzman/Colleen O'Brien, The American Society of Mechanical Engineering (ASME)

**RECOMMENDATION:**

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

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<td>Piping</td>
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<tr>
<td>ASME B1.20.1-1983 (R2006) 2013*</td>
<td>Pipe Threads, General Purpose (Inch)</td>
<td>Joints</td>
<td>1308.5.9</td>
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<tr>
<td>ASME B1.20.3-1976 (R2006) (R2013)*</td>
<td>Dryseal Pipe Threads (Inch)</td>
<td>Joints</td>
<td>103.1, 306.1</td>
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<tr>
<td>ASME B16.3-2006 2011*</td>
<td>Malleable Iron Threaded Fittings: Classes 150 and 300</td>
<td>Fittings</td>
<td>Table 1201.3.1</td>
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<tr>
<td>ASME B16.5-2009 2013*</td>
<td>Pipe Flanges and Flanged Fittings: NPS ½ through 24 Metric/Inch</td>
<td>Fittings</td>
<td>Table 1201.3.1</td>
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<tr>
<td>ASME B16.9-2007 2012*</td>
<td>Factory-Made Wrought Buttwelding Fittings</td>
<td>Fittings</td>
<td>Table 1201.3.1</td>
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<tr>
<td>ASME B16.11-2009 2011</td>
<td>Forged Fittings, Socket-Welding and Threaded</td>
<td>Fittings</td>
<td>Table 1201.3.1</td>
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<td>ASME B16.15-2006 2013*</td>
<td>Cast Copper Alloy Threaded Fittings: Classes 125 and 250</td>
<td>Fittings</td>
<td>Table 1201.3.1</td>
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<tr>
<td>ASME B16.18-2004 (R2005) 2012*</td>
<td>Cast Copper Alloy Solder Joint Pressure Fittings (Note 1)</td>
<td>Fittings</td>
<td>Table 1201.3.1</td>
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SUBSTANTIATION:
The above revisions reflect the latest updates to the ASME standards that are referenced in Table 1701.0. These updates were not available at the time the ROP Monograph was published.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
RECOMMENDATION:
Revise text as follows:

TABLE 1701.0
REFERRED STANDARDS

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<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<tr>
<td>CSA LC 1a-2009-2011</td>
<td>Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing (CSST) (same as CSA 6.26a)</td>
<td>Fuel Gas</td>
<td>1308.5.3.4</td>
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<tr>
<td>CSA LC 4-2007 (R2012)</td>
<td>Press-Connect Copper and Copper Alloy Fittings For Use in Fuel Gas Distribution Systems (same as CSA 6.32)</td>
<td>Fuel Gas</td>
<td>1308.5.10.2</td>
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<tr>
<td>CSA Z21.5.1a-2007 (R2011)</td>
<td>Gas Clothes Dryers-Volume I, Type I Clothes Dryers (same as CSA 7.1a)</td>
<td>Fuel Gas, Appliances</td>
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<tr>
<td>CSA Z21.5.2a-2006 (R2010) (R2011)</td>
<td>Gas Clothes Dryers-Volume II, Type 2 Clothes Dryers (same as CSA 7.2a)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.10.1a-2009 2011</td>
<td>Gas Water Heaters-Volume I, Storage Water Heaters with Input Ratings of 75 000 Btu Per Hour or Less (same as CSA 4.1ab)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.10.3b-2008 (R2010) 2011</td>
<td>Gas Water Heaters-Volume III, Storage Water Heaters with Input Ratings Above 75 000 Btu Per Hour, Circulating and Instantaneous (same as CSA 4.3b)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.11.2-2010 2011</td>
<td>Gas-Fired Room Heaters, Volume II, Unvented Room Heaters</td>
<td>Room Heaters, Unvented Heaters</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.13b-2010-2012</td>
<td>Gas-Fired Low Pressure Steam and Hot Water Boilers (same as CSA 4.9b)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.15g-2009 2012</td>
<td>Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves (same as CSA 9.1g)</td>
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</tr>
<tr>
<td>CSA Z21.18ab-2010 2012 (R2012)</td>
<td>Gas Appliance Pressure Regulators (same as CSA 6.3b)</td>
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<td>103.1, 306.1</td>
</tr>
<tr>
<td>CSA Z21.19a-R2009 (R2011)</td>
<td>Refrigerators Using Gas Fuel (same as CSA 1.4a)</td>
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<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.21ah-2010 2011</td>
<td>Automatic Valves for Gas Appliances (same as CSA 6.5ab)</td>
<td>Appliance Valves, Automatic Gas Valves, Valves</td>
<td>103.1, 306.1</td>
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</table>
**SUBSTANTIATION:**
The above revisions reflect the latest updates to the CSA standards that are referenced in Table 1701.0. Furthermore, CGA 2.91a and CGA 6.14 have been replaced with CSA Z21.40.1a and CSA Z21.66.

**COMMITTEE ACTION:** Accept as Submitted

**A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.**

**PUBLIC COMMENT:**
**SUBMITTER:** Lauro Pilla/Nikki Kidd, Canadian Standards Association (CSA)

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

<table>
<thead>
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<tr>
<td>CSA Z21.24a-2009 (R2011)*</td>
<td>Connectors for Gas Appliances (same as CSA 6.10a)</td>
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<tr>
<td>CSA Z21.41b-2010 2011*</td>
<td>Quick Disconnect Devices for Use with Gas Fuel Appliances (same as CSA 6.9b)</td>
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<tr>
<td><strong>CSA Z21.47b-2008 2012</strong></td>
<td>Gas-Fired Central Furnaces (same as CSA 2.3b)</td>
<td>Fuel Gas, Appliances</td>
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<td>CSA Z21.58ab-2008 2012*</td>
<td>Outdoor Cooking Gas Appliances (same as CSA 1.6ab)</td>
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<tr>
<td><strong>CSA Z21.69g-2009 2012</strong></td>
<td>Connectors for Moveable Gas Appliances (same as CSA 6.16a)</td>
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<td><strong>CSA Z21.80b-2010 2011</strong></td>
<td>Line Pressure Regulators (same as CSA 6.22b)</td>
<td>Fuel Gas</td>
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<tr>
<td>*<em>CSA Z21.90b-2006 (R2011)</em></td>
<td>Gas Convenience Outlets and Optional Enclosures (same as CSA 6.24b)</td>
<td>Gas Outlets</td>
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<td>CSA Z83.7b-2009 2011*</td>
<td>Gas-Fired Construction Heaters (same as CSA 2.14b)</td>
<td>Fuel Gas Appliances</td>
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<td>CSA Z83.11b-2009 (R2011)*</td>
<td>Gas Food Service Equipment (same as CSA 1.8b)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z83.19g-2009 2011*</td>
<td>Gas-Fired High-Intensity Infrared Heaters (same as CSA 2.35g)</td>
<td>High Intensity Heaters, Infrared Heaters</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z83.20ab-2010 2011*</td>
<td>Gas-Fired Low-Intensity Infrared Heaters (same as CSA 2.34ab)</td>
<td>Infrared Heaters, Low Intensity Heaters</td>
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(portions of table not shown remain unchanged)
## Table 1701.0
### Referenced Standards

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<tr>
<td>CSA B137.1-2009 2013</td>
<td>Polyethylene (PE) Pipe, Tubing, and Fittings for Cold-Water Pressure Services</td>
<td>Piping, Plastic</td>
<td>E 505.1.2, Table 1201.3.1</td>
</tr>
<tr>
<td>CSA B137.2-2009 2013</td>
<td>Polyvinylchloride (PVC) Injection-Moulded Gasketed Fittings for Pressure Application</td>
<td>Piping, Plastic</td>
<td>Table E 505.6</td>
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<tr>
<td>CSA B137.3-2009 2013</td>
<td>Rigid Polyvinylchloride (PVC) Pipe and Fittings for Pressure Applications</td>
<td>Piping, Plastic</td>
<td>Table E 505.6</td>
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<td>CSA B137.5-2009 2013</td>
<td>Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications</td>
<td>Piping, Plastic</td>
<td>Table 1201.3.1</td>
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<tr>
<td>CSA B137.6-2009 2013</td>
<td>Chlorinated Polyvinylchloride (CPVC) Pipe, Tubing, and Fittings for Hot-and Cold-Water Distribution Systems</td>
<td>Piping, Plastic</td>
<td>Table E 505.6</td>
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<tr>
<td>CSA B137.9-2009 2013</td>
<td>Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure-Pipe Systems</td>
<td>Piping, Plastic</td>
<td>Table 1201.3.1</td>
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<td>CSA B137.10-2009 2013</td>
<td>Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Composite Pressure-Pipe Systems</td>
<td>Piping, Plastic</td>
<td>Table 1201.3.1</td>
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<tr>
<td>CSA B137.11-2009 2013</td>
<td>Polypropylene (PP-R) Pipe and Fittings for Pressure Applications</td>
<td>Piping, Plastic</td>
<td>Table E 505.5</td>
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<tr>
<td>CSA C448-2002 2013</td>
<td>Design and Installation of Earth Energy Systems</td>
<td>Miscellaneous</td>
<td>E 505.1.1</td>
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<tr>
<td>CSA LC4a-2007 <em>(R2012)</em> 2013*</td>
<td>Press-Connect Copper and Copper Alloy Fittings For Use in Fuel Gas Distribution Systems (same as CSA 6.32a)</td>
<td>Fuel Gas</td>
<td>1308.5.10.2</td>
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<tr>
<td>CSA Z21.5.2-2006 <em>(R2011)</em> 2013*</td>
<td>Gas Clothes Dryers-Volume II, Type 2 Clothes Dryers (same as CSA 7.2a)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
</tr>
<tr>
<td>CSA Z21.10.1b-2011 2013*</td>
<td>Gas Water Heaters-Volume I, Storage Water Heaters with Input Ratings of 75 000 Btu Per Hour or Less (same as CSA 4.1b)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.10.3-2011 2013*</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>103.1, 306.1</td>
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<tr>
<td>CSA Z21.11.2-2011 2013*</td>
<td>Gas-Fired Room Heaters, Volume II, Unvented Room Heaters</td>
<td>Room Heaters, Unvented Heaters</td>
<td>103.1, 306.1</td>
</tr>
<tr>
<td>CSA Z21.13b-2012 2013*</td>
<td>Gas-Fired Low Pressure Steam and Hot Water Boilers (same as CSA 4.9b)</td>
<td>Fuel Gas, Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.15a-2012 2013*</td>
<td>Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves (same as CSA 9.1ab)</td>
<td>Fuel Gas</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.50b-2009 2012*</td>
<td>Vented Gas Fireplaces (same as CSA 2.22b)</td>
<td>Appliances, Decorative Appliances</td>
<td>103.1, 306.1</td>
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<tr>
<td>CSA Z21.80g-2011 2012*</td>
<td>Line Pressure Regulators (same as CSA 6.22a)</td>
<td>Fuel Gas</td>
<td>1308.7.2, 1308.7.5.1(1)</td>
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<td>CSA Z21.88g-2010 2012*</td>
<td>Vented Gas Fireplace Heaters (same as CSA 2.33g)</td>
<td>Fireplace Heaters</td>
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SUBSTANTIATION:
The above revisions reflect the latest updates to the CSA standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
SUBMITTER: Kyle Thompson
International Association of Plumbing and Mechanical Officials (IAPMO)

RECOMMENDATION:
Revise text as follows:

TABLE 1701.0
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
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<tr>
<td>IAPMO PS 117-2008 2012a1</td>
<td>Copper and Copper Alloy Tubing System Incorporating Press-Type or Nail-Type Connections Press and Nail Connection Systems</td>
<td>Fittings</td>
<td>103.1, 306.1</td>
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</tbody>
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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the IAPMO standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Kyle Thompson, International Association of Plumbing and Mechanical Officials (IAPMO)

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

TABLE 1701.0
REFERENCED STANDARDS

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<tr>
<td>IAPMO PS 42-2010a Z1033-2013a2</td>
<td>Flexible PVC Hoses and Tubing for Pools, Hot Tubs, Spas and Jetted Bathubs</td>
<td>Swimming Pools, Spas, and Hot Tubs</td>
<td>USPSHTC</td>
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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the IAPMO standards that are referenced in Table 1701.0.

Note: This public comment is not in compliance with Section 1.2 (Code References) of the “Guidelines for Referencing Mandatory Standards” which was adopted by the IAPMO Standards Council on August 21, 2013. For informational purposes only, Section 1.2 (Code References) is shown as follows: Mandatory standards shall be identifiable by title, date or edition, and name of the developing organization. The manner in which it is to be utilized shall be specifically referenced in the Code text (referenced section that applies), all in accordance with the IAPMO Manual of Style.

COMMITTEE ACTION: Accept the public comment as submitted
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
SUBMITTER: Robert O’Neill
Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

RECOMMENDATION:
Revise text as follows:

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<td>MSS SP-6-2007* 2012</td>
<td>Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings</td>
<td>Miscellaneous</td>
<td>1308.5.12</td>
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<td>MSS SP-67-2002a 2011*</td>
<td>Butterfly Valves</td>
<td>Valves</td>
<td>103.1, 306.1</td>
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<tr>
<td>MSS SP-69-2003* (D)</td>
<td>Pipe Hangers and Supports-Selection and Application (Discontinued)</td>
<td>Miscellaneous</td>
<td>103.1, 306.1</td>
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<td>MSS SP-89-2002* (D)</td>
<td>Pipe Hangers and Supports—Fabrication and Installation Practices (Discontinued)</td>
<td>Miscellaneous</td>
<td>103.1, 306.1</td>
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<td>MSS SP-104-2003* 2012*</td>
<td>Wrought Copper Solder-Joint Pressure Fittings</td>
<td>Fittings</td>
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<td>MSS SP-106-2003* 2012*</td>
<td>Cast Copper Alloy Flanges and Flanged Fittings: Class 125, 150, and 300</td>
<td>Fittings</td>
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</table>

(portions of table not shown remain unchanged)

SUBSTANTIATION:
1. The above revisions reflect the latest updates to the MSS standards that are referenced in Table 1701.0.
2. The MSS SP-58-2009 “comprehensive” edition integrates the content of a revised MSS SP-58 with ANSI/MSS SP-69-2003, MSS SP-77-1995 (R2000), MSS SP-89-2003, and MSS SP-90-2000 into a single source document; enabling the user to specify a minimum level of acceptance for pipe hanger design and performance, in addition to defining the types of hangers and supports. The aforementioned MSS SP-69 will not be revised and MSS 89 was withdrawn in 2010. The ANSI/MSS SP-58-2009 edition supplants, and can officially be utilized and referenced in place of, the aforementioned MSS SP-69 and MSS SP-89.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: David Thompson, Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
TABLE 1701.0
REFERENCED STANDARDS

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<td>MSS SP-80-2008</td>
<td>Bronze Gate, Globe, Angle, and Check Valves</td>
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(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the MSS standards that are referenced in Table 1701.0.

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:** AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
Item # 361

SUBMITTER: Denise Beach
National Fire Protection Association (NFPA)

RECOMMENDATION:
Revise text as follows:

TABLE 1701.0
REFERENCED STANDARDS

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<td>NFPA 13-2010 2013*</td>
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<td>Miscellaneous</td>
<td>513.2.2.1(2), 517.7.6</td>
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<td>NFPA 30-2008 2012*</td>
<td>Flammable and Combustible Liquids Code</td>
<td>Combustible Liquids, Flammable Liquids</td>
<td>103.1, 306.1</td>
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<td>NFPA 90A-2009 2012*</td>
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<td>NFPA 221-2009 2012*</td>
<td>High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls</td>
<td>Building Fire Walls, Fire Barrier</td>
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<tr>
<td>NFPA 251-2011* (D)</td>
<td>Test of Fire Resistance of Building Construction and Materials (Discontinued)</td>
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<tr>
<td>NFPA 654-2006 2012*</td>
<td>Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids</td>
<td>Dust Explosion Prevention, Gutters</td>
<td>506.4</td>
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(portions of table not shown remain unchanged)

208.0

Fire Resistance Rating. A relative value in minutes or hours assigned to materials or assemblies that have withstood a fire exposure as established in accordance with NFPA 254, ASTM E119 or UL 263. [NFPA 96.3.3.26]

SUBSTANTIATION:
The above revisions reflect the latest updates to the NFPA standards that are referenced in Table 1701.0. Furthermore, NFPA 251 has been withdrawn, and therefore the appropriate test methods can be found in ASTM E119 and UL 263.

COMMITTEE ACTION: Accept as Submitted
A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: National Fire Protection Association (NFPA)

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

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<td>Portable Fire Extinguishers</td>
<td>Fire Extinguishing</td>
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<tr>
<td>NFPA 17-2009</td>
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<td>Building Construction and Safety Code</td>
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(portions of table not shown remain unchanged)

SUBSTANTIATION:
The above revisions reflect the latest updates to the NFPA standards that are referenced in Table 1701.0. Furthermore, NFPA 5000 should be editorially added to Table 1701.0 as language is being extracted from NFPA 5000 in Section 205.0 for the definitions for “ceiling radiation damper” and “combination fire and smoke damper.”

COMMITTEE ACTION: Accept the public comment as submitted
TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
**SUBMITTER:** Bob Eugene  
UL LLC

**RECOMMENDATION:**  
Revise text as follows:

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<td>UL 125-2009*</td>
<td>Flow Control Valves for Anhydrous Ammonia and LP-Gas (with revisions through February 26, 2010 November 10, 2011)</td>
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<td>UL 127-2008 2011*</td>
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<td>UL 144-1999 2012*</td>
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<td>UL 197-2010*</td>
<td>Commercial Electric Cooking Appliances (with revisions through June 24, 2011)</td>
<td>Appliances, Commercial Cooking, Electric Appliances</td>
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<tr>
<td>UL 296-2003*</td>
<td>Oil Burners (with revisions through March 5, 2010 June 15, 2011)</td>
<td>Fuel Gas, Appliances</td>
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<td>UL 352-2006* (D)</td>
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<td>Flame Arresters (with revisions through August 10, 2012)</td>
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<td>Fuel Gas, Appliances</td>
<td>1002.2.1</td>
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SUBSTANTIATION:
The above revisions reflect the latest updates to the UL standards that are referenced in Table 1701.0.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.

PUBLIC COMMENT:
SUBMITTER: Marguerite Carroll, UL, LLC

RECOMMENDATION:
Request to accept the code change proposal as modified by this public comment.
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<td>UL 2200-2012*</td>
<td>Stationary Engine Generator Assemblies (with revisions through June 7, 2013)</td>
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(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
The above revisions reflect the latest updates to the UL standards that are referenced in Table 1701.0.

**COMMITTEE ACTION:** Accept the public comment as submitted

**TOTAL ELIGIBLE TO VOTE:** 22

**VOTING RESULTS:**  AFFIRMATIVE: 21  NOT RETURNED: 1 Garza
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 101.0 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 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 201.3 Geothermal. Renewable energy generated by deep-earth.
E 201.4 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 201.5 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 201.6 Integrated Part-Load Value (IPLV). A single-number figure of merit based on part-load EER, COP, 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 201.7 Maintenance. The upkeep of property or equipment by the owner of the property in accordance with the requirements of this appendix.
E 201.8 Minimum Efficiency Reporting Value (MERV). Filter minimum efficiency reporting value, in accordance with ASHRAE 52.2.
E 201.9 Multi-Occupant Spaces. Indoor spaces used for presentations and training, including classrooms and conference rooms.
E 201.10 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 201.11 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 (ft³/min) (14.1584 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 of cooling where system controls are set to maximum water use. Water use, expressed in maximum water use per ton-hour 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 airgap 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 403.45 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 403.45.1 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 403.45.2 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 equipment using single-phase electric power, air conditioners, and heat pumps with rated cooling capacities less than 65 000 British thermal units per hour (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 comply 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 [2.86 E-11 kg/(Pa*s*m²)] where tested in accordance with Procedure A in ASTM E96.

Insulation is not 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 [0.00005 (m³/s)/m²] of duct surface area in accordance with the SMACNA 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]

### TABLE E 502.5

**MINIMUM PIPE INSULATION THICKNESS1, 5**

[ASHRAE 90.2: TABLE 6.5]

<table>
<thead>
<tr>
<th>FLUID DESIGN OPERATING TEMPERATURE RANGE (°F)</th>
<th>INSULATION CONDUCTIVITY [Btu·inch/(h·ft²·°F)]</th>
<th>MEAN RATING TEMPERATURE (°F)</th>
<th>NOMINAL PIPE DIAMETER (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEATING SYSTEMS (STEAM, STEAM CONDENSATE, AND HOT WATER)2, 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>201–250</td>
<td>0.27–0.30</td>
<td>150</td>
<td>1.5</td>
</tr>
<tr>
<td>141–200</td>
<td>0.25–0.29</td>
<td>125</td>
<td>1.0</td>
</tr>
<tr>
<td>105–140</td>
<td>0.22–0.28</td>
<td>100</td>
<td>0.5</td>
</tr>
<tr>
<td>COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40–55</td>
<td>0.22–0.28</td>
<td>100</td>
<td>0.5</td>
</tr>
<tr>
<td>Below 40</td>
<td>0.22–0.28</td>
<td>100</td>
<td>0.5</td>
</tr>
</tbody>
</table>

For SI Units: °C= (°F-32)/1.8, 1 British thermal unit inch per hour 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:

\[ T = r\left\{\left(1 + t/r\right)^K/k - 1\right\} \]

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 \( \frac{1}{2} \) 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 crawlspaces are considered exposed to outdoor air.

**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. [ASHRAE 90.2:6.6.1]
Mechanical Ventilation = \[\frac{(0.35 - \text{Summer}) \times \text{Volume}}{60}\]

Where:
- Mechanical Ventilation = required mechanical ventilation rate to supplement summer infiltration, cfm
- Summer = summer design infiltration rate, ach
- Volume = volume of conditioned space, ft\(^3\)

For SI units: 1 cubic foot per minute = 0.00047 m\(^3\)/s, 1 cubic foot = 0.0283 m\(^3\)

**TABLE E 502.6**

**VENTILATION AIR**

[ASHRAE 90.2: TABLE 6.6.1]

<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 502.6.1 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]

**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 deadband, the range of which includes a setting of 10°F (-12°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 shutoff. 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 shutoff. [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 relative humidity within the space above 30 percent. [ASHRAE 90.2:6.10.3.1]

**E 502.10.3.1 Cooling.** Where additional energy-consuming equipment is provided for reducing humidity, it shall be equipped with controls 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 shutting 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 shutting 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 shutoff where the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible. [ASHRAE 90.1:6.4.3.8]

**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.

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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 @ 70°F Ent. Water</td>
<td>ARI 325</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.5 EER @ 50°F Ent. Water</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td>Heating Mode</td>
<td>3.4 COP @ 70°F Ent. Water</td>
<td>ARI 325</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0 COP @ 50°F Ent. Water</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Unitary A/C</td>
<td>Water cooled split system</td>
<td>9.1 EER @ 85°F Ent. Water</td>
<td>ARI 210/240</td>
</tr>
<tr>
<td></td>
<td>Evaporatively cooled split system</td>
<td>8.3 IPLV @ 75°F Ent. Water</td>
<td>ARI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.1 EER @ 95°F Out. Amb.</td>
<td>ARI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.5 IPLV @ 80°F Out. Amb</td>
<td>ARI 210/240</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 Standard 325.

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**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 this section.
E 503.1.1 New Buildings. Mechanical equipment and systems serving the heating, cooling, or ventilating 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, or ventilating needs of additions to existing buildings shall be in accordance with the requirements of this section as described in Section E 503.2. [ASHRAE 90.1:6.1.1.2]

Exception: Where HVAC to an addition is provided by existing HVAC systems and equipment, such existing systems and equipment shall not be required to be in accordance with this appendix. However, new systems or equipment installed shall be in accordance with specific requirements applicable to those systems and equipment. [ASHRAE 90.1:6.1.1.2]

E 503.1.3 Alterations to Heating, Ventilating, and Air-Conditioning in Existing Buildings. New HVAC equipment as a direct replacement of existing HVAC equipment shall be in accordance with the specific minimum efficiency requirements applicable to that equipment. [ASHRAE 90.1:6.1.1.3.1]

E 503.1.3.1 New Cooling Systems. New cooling systems installed to serve previously uncooled spaces shall be in accordance with this section as described in Section E 503.2. [ASHRAE 90.1:6.1.1.3.2]

E 503.1.3.2 Existing Cooling Systems. Alterations to existing cooling systems shall not decrease economizer capability unless the system is in accordance with Section E 503.5 through Section 503.5.4. [ASHRAE 90.1:6.1.1.3.3]

E 503.1.3.3 Ductwork. New and replacement ductwork (insulation of) shall comply with Section E 503.4.4.1 and Section E 503.4.4.2. [ASHRAE 90.1:6.1.1.3.4]

E 503.1.3.4 Piping. New and replacement piping shall comply with Section E 503.4.4.1 and Section E 503.4.7.1.

Exceptions: Compliance shall not be required for the following:
1. Equipment that is being modified or repaired but not replaced, provided that such modifications, repairs for the following or both will not result in an increase in the annual energy consumption of the equipment using the same energy type.
2. 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. Refrigerant change of existing equipment.
4. Relocation of existing equipment.
5. Ducts and pipes where there is insufficient space or access to meet these requirements. [ASHRAE 90.1:6.1.1.3.5]

E 503.2 Compliance Path(s). Compliance with Section E 503.0 shall be achieved by meeting in accordance with the requirements for of Section E 503.1, Section E 503.6, Section E 503.7, and either one of the following:
1. Section E 503.3.
2. Section E 503.4 and Section E 503.5. [ASHRAE 90.1:6.2.1.1]

Exception: Projects using the energy cost budget method of Section 11 of in accordance with ASHRAE 90.1, provided such projects are in accordance 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 is an optional path for compliance where the following conditions are met:
1. Building is not more than two stories in height.
2. Gross floor area is less than 25 000 square feet (2322.6 m²).
3. Each 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 meet comply with the following criteria:
1. The system serves a single HVAC zone. [ASHRAE 90.1:6.3.2(a)]
2. The equipment shall meet comply with the variable flow requirements of Section E 503.4.3.10 and Section E 503.4.6.11. [ASHRAE 90.1:6.3.2(b)]
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 meeting in accordance with the requirements shown in Table E 503.7.1(1) (air conditioners), Table E 503.7.1(2) (heat pumps), or Table E 503.7.1(4) (package terminal and room air conditioners and heat pumps) for the applicable equipment category. [ASHRAE 90.1:6.3.2(c)]
4. The system shall have an air economizer in accordance with Section E 503.5.1, where indicated in Table E 503.5, with controls as indicated in Table E 503.5.1.2(1) and Table E 503.5.1.2(2) and with either barometric or powered relief sized to prevent overpressurization of the building. Where the cooling efficiency meets or exceeds the efficiency requirement in Table E 503.3.1, no economizer is required. Outdoor air dampers for economizer use shall be provided with blade and jamb seals. [ASHRAE 90.1:6.3.2(d)]
(5) Heating shall be provided by a unitary packaged or split-system heat pump that meets the applicable efficiency requirements shown in Table E 503.7.1(2) (heat pumps) or Table E 503.7.1(4) (packaged terminal and room air conditioners and heat pumps), a fuel-fired furnace that meets the applicable efficiency requirements shown in Table E 503.7.1(5) (furnaces, duct furnaces, and unit heaters), an electric resistance heater, or a baseboard system connected to a boiler that meets the applicable efficiency requirements shown in Table E 503.7.1(6) (boilers). [ASHRAE 90.1:6.3.2(e)]

(6) The outdoor air quantity supplied by the system shall be less than or equal to 3000 cubic feet per minute (ft³/min) (1.4158 m³/s) and less than 70 percent of the supply air quantity at minimum outdoor air design conditions unless an energy recovery ventilation system is provided in accordance with the requirements in Section E 503.5.10. [ASHRAE 90.1-07:6.3.2(e)]

The system shall comply with the exhaust air energy requirements in accordance with of Section E 503.5.10. [ASHRAE 90.1:6.3.2(f)]

(7) The system shall be controlled by a manual changeover or dual setpoint thermostat. [ASHRAE 90.1:6.3.2(g)]

(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 is permitted during outdoor coil defrost cycles. Two means of meeting this requirement are: 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 outside air temperature is less than 40°F (4°C). Heat pumps whose minimum efficiency is regulated by NAECA and whose HSPF rating both meet the requirements shown in Table E 503.7.1(2) and includes usage of internal electric resistance heating are exempted from the control requirements of this part [Section E 503.3.1(8)]. [ASHRAE 90.1:6.3.2(h)]

(9) The system controls shall not permit reheat or other form of simultaneous heating and cooling for humidity control. [ASHRAE 90.1:6.3.2(i)]

(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 greater than 15 000 Btu/h (4.4 kW) and a supply fan motor power greater 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) 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) Capable of temperature setback down to 55°F (13°C) during off hours.

(e) Capable of temperature setup to 90°F (32°C) during off hours. [ASHRAE 90.1:6.3.2(j)]

(11) Except for piping within manufacturer’s units, HVAC piping shall be insulated in accordance with Table E 503.7.2(4) and Table 503.7.2(4). 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. [ASHRAE 90.1:6.3.2(k)]

(12) Ductwork and plenums shall be insulated in accordance with Table E 503.7.2(4) and Table E 503.7.42(4) and shall be sealed in accordance with Table E 503.4.42.2(1). [ASHRAE 90.1:42.6.3.2(kl)]

(13) Construction documents shall require a ducted system to be air balanced in accordance with industry-accepted procedures. [ASHRAE 90.1:6.3.2(m)]

(14) Outdoor air intake and exhaust systems shall comply with Section E 503.4.6.4. [ASHRAE 90.1:6.3.2(n)]

(145) Where separate heating and cooling equipment serves the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling. [ASHRAE 90.1:6.3.2(o)]

(15) Exhausts with a design capacity of over 300 ft³/min (0.142 m³/s) on systems that do not operate continuously shall be equipped with gravity or motorized dampers that will automatically shut where the systems are not in use. [ASHRAE 90.1-07:6.3.2(n)]

(16) Systems with a design supply air capacity more than 10 000 ft³/min (4.7195 m³/s) shall have optimum start controls. [ASHRAE 90.1:6.3.2(p)]

(17) The system shall comply with the demand control ventilation requirements of Section E 503.4.6.10. [ASHRAE 90.1:6.3.2(q)]
TABLE E 503.3.1
ELIMINATE REQUIRED ECONOMIZER FOR COMFORT COOLING BY INCREASING COOLING EFFICIENCY
[ASHRAE 90.1:07: TABLE 6.3.2]

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

Notes:
1 Each EER shown should be reduced by 0.2 for units with a heating section other than electric resistance heat.
2 Elimination of required economizer is not allowed.
3 Section 12 of ASHRAE 90.1 contains complete specification of the referenced test procedure, including the referenced year version of the test procedure.

<table>
<thead>
<tr>
<th>SYSTEM SIZE (kBtu/h)</th>
<th>MANDATORY MINIMUM EER*</th>
<th>CLIMATE ZONES</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>6</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>≥65 and &lt;135</td>
<td>10.1</td>
<td>N/A*</td>
<td>12.0</td>
</tr>
<tr>
<td>≥135 and &lt;240</td>
<td>0.3</td>
<td>N/A*</td>
<td>14.3</td>
</tr>
<tr>
<td>≥240 and &gt;760</td>
<td>0.0</td>
<td>N/A*</td>
<td>16.0</td>
</tr>
</tbody>
</table>

OTHER UNITARY SYSTEMS

<table>
<thead>
<tr>
<th>SYSTEM SIZE (kBtu/h)</th>
<th>MANDATORY MINIMUM EER*</th>
<th>CLIMATE ZONES</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td>6</td>
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<tr>
<td></td>
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<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>≥65 and &lt;135</td>
<td>10.3</td>
<td>N/A*</td>
<td>12.8</td>
</tr>
<tr>
<td>≥135 and &lt;240</td>
<td>0.2</td>
<td>N/A*</td>
<td>14.5</td>
</tr>
<tr>
<td>≥240 and &gt;760</td>
<td>0.0</td>
<td>N/A*</td>
<td>16.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLIMATE ZONE</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>
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<tr>
<td>5b</td>
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<td>5c</td>
<td>74%</td>
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<tr>
<td>6a</td>
<td>56%</td>
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<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 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 (EER or COP cooling) then the full load shall be increased by the percentage shown.

E 503.3.2 Climate Zone Determination. Climate zones identified in this appendix shall be determined in accordance with Section 5.1.4 of ASHRAE 90.1.

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(21) 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 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. Equip-
ment used to provide water heating functions as part of a combination system shall satisfy stated requirements for the appropriate space heating or cooling category.

Tables are as follows:

1. Table E 503.7.1(1) – Air Conditioners and Condensing Units
2. Table E 503.7.1(2) – Heat Pumps
3. Table E 503.7.1(3) – Water-Chilling Packages (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) – Packaged Terminal, Room Air Conditioners and Heat Pumps
5. Table E 503.7.1(5) – Furnaces, Duct Furnaces, and Unit Heaters
6. Table E 503.7.1(6) – Boilers
7. Table E 503.7.1(7) – Heat Rejection Equipment
8. Table E 503.7.1(8) – Heat Transfer Equipment
9. Table E 503.7.1(9) – Variable Refrigerant Flow Air Conditioners
10. Table E 503.7.1(10) – Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps
11. Table E 503.7.1(11) – Air Conditioners Serving Computer Rooms

Furnaces with input ratings of not less than 225 000 Btu/h (66 kW), 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 under the scope of ASHRAE 127 shall be in accordance with Table E 503.7.1(11). Other air conditioners shall comply with Table E 503.7.1(1). [ASHRAE 90.1-07:6.4.1.1]

E 503.4.1 Minimum Equipment Efficiencies-Listed Equipment-Nonstandard Conditions. Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions [and, thus, cannot be tested to meet the requirements of Table E 503.7.1(3)] of 44°F (7°C) leaving chilled-water temperature and 85°F (29°C) entering condenser-water temperature with 3 gallons per minute per ton [(gal/min)/ton] [0.0002 (L/s)/kg] condenser-water flow shall have a maximum full-load and NPLV ratings. Adjusted using the following equation: [ASHRAE 90.1-07:6.4.1.2]

(Equation E 503.4.1)

\[
\text{Adjusted maximum full-load kW/ton rating} = \frac{\text{full-load kW/ton from Table E 503.7.1(3)}}{K_{adj}}
\]

\[
\text{Adjusted maximum NPLV rating} = \frac{\text{IPLV from Table E 503.7.1(3)}}{K_{adj}}
\]

Where:

\[
K_{adj} = 6.174722 - 0.303668(X) + 0.00629466(X)^2 - 0.000045780(X)^3
\]

\[
X = DT_{std} - LIFT
\]

\[
DT_{std} = (24 + (\text{full-load kW/ton from Table E 503.7.1(3)} \times 6.83) / \text{Flow}
\]

\[
\text{Flow} = \text{Condenser water flow (gpm)/Cooling full-load capacity (tons)
}\]

\[
LIFT = CEWT - CLWT
\]

\[
CEWT = \text{Full-load condenser entering water temperature, (°F)
}\]

\[
CLWT = \text{Full-load leaving chilled-water temperature, (°F)
}\]

The adjusted full-load and NPLV values are applicable over the following full-load design ranges:

1. Leaving Chiller Water Temperature: 38°F (3.3°C)
2. Entering Condenser Water Temperature: 102°F (39°C)
3. Condenser Water Flow: 1 to 6 (gal/min)/ton [6 E-05 (L/s)/kg to 4 E-04 (L/s)/kg]
4. \(X \geq 39°F (3.9°C) \) and \( \leq 60°F (16°C) \)

Chillers designed to operate outside of these ranges or applications utilizing fluids or solutions with secondary coolants (e.g., glycol solutions or brines) with a freeze point of 27°F (-3°C) or lower for freeze protection are not covered by this appendix. [ASHRAE 90.1-07:6.4.1.2]

Example: Path A 600 ton (600 000 kg) centrifugal chiller
Table E 503.7.1(3) efficiencies as of 1/1/2010

\[
\text{Full Load} = 0.570 \text{ kW/ton}
\]

\[
\text{IPLV} = 0.530 \text{ kW/ton}
\]

\[
\text{CEWT} = 80°F
\]
Flow = 2.5 gal/min/ton

CLWT = 42°F

LIFT = 80 – 42 = 38°F

DT = (24 + 0.570 × 6.83)/2.5 = 11.16°F

X = 38 + 11.16 = 49.16°F

\[ K_{adj} = 6.174772 - 0.303668(49.16) + 0.00629466(49.16)^2 - 0.00004578 (49.16)^3 = 1.020 \]

Adjusted full load = 0.570/1.020 = 0.559 kW/ton

NPLV = 0.539/1.020 = 0.528 kW/ton

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 Water-Cooled Centrifugal Chilling Packages. Equipment not designed for operation in accordance with AHRI 550/590 test conditions of 44°F (7°C) leaving chilled fluid temperature at 85°F (29°C) entering condenser-fluid temperature with 3 gallons per minute per ton (gpm/ton) (0.0002 L/s/kg) condenser-fluid flow shall have maximum full-load kW/ton and NPLV ratings adjusted using the following equation:

(Equation E 503.4.1)

Adjusted maximum full-load kW/ton rating = [full-load kW/ton from Table E 503.7.1(3)]/K_ad

Adjusted maximum NPLV rating = [IPLV from Table E 503.7.1(3)]/K_ad

\[ K_{adj} = A \times B \]

Where:

\[ A = 0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302 \]

\[ B = 0.0015 \times LvgEvap + 0.934 \]

\[ LIFT = LvgCond - LvgEvap \]

LvgCond = Full-load condenser leaving fluid temperature (°F)

LvgEvap = Full-load evaporator leaving temperature (°F)

The adjusted full-load and NPLV values shall only be applicable for centrifugal chillers in accordance with the following full-load design ranges:

(1) Minimum Evaporator Leaving Temperature: 36°F
(2) Maximum Condenser Leaving Temperature: 115°F
(3) LIFT is not less than 20°F and not more than 80°F

Manufacturers shall calculate the adjusted maximum kW/ton and NPLV before determining whether to label the chiller in accordance with Section E 503.4.4. Chillers shall be labeled in accordance with this appendix.

Centrifugal chillers designed to operate outside of these ranges are not covered under this appendix.

Example: Path A 600 ton (600 000 kg) centrifugal chiller Table E 503.7.1(3) efficiencies.

\[ \text{Full Load} = 0.570 \text{ kW/ton} \]

\[ \text{IPLV} = 0.539 \text{ kW/ton} \]

\[ LvgCond = 91.16°F \]

\[ LvgEvap = 42°F \]

\[ LIFT = 91.16 - 42 = 49.16°F \]

\[ K_{adj} = A \times B \]

\[ A = 0.00000014592 \times (49.16)^4 - 0.0000346496 \times (49.16)^3 + 0.00314196 \times (4916)^2 - 0.147199 \times (4916) + 3.9302 = 1.0228 \]

\[ B = 0.0015 \times 42 + 0.934 = 0.9970 \]

Adjusted full load = 0.570/(1.0228 x 0.9970) = 0.559 kW/ton

NPLV = 0.539/(1.0228 x 0.9970) = 0.529 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 higher than 32°F (0°C) shall be in accordance with Table E 503.7.1(3) where tested or certified with water at standard rating conditions, in accordance with the referenced test procedure. [ASHRAE 90.1:6.4.1.2.1]
E 503.4.1-42 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 503.4.1-23 Verification of Equipment Efficiencies. Equipment efficiency information supplied by manufacturers shall be verified as follows:

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 meets the minimum equipment efficiency requirements in Section E 503.4 through Section E 503.4.4.4.

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 503.4.1-34 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 503.4.3-3(A)4.1 Packaged Terminal Air Conditioners. Nonstandard size packaged terminal air conditioners and heat pumps with existing sleeve 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 as follows:

1. Manufactured for nonstandard size applications only not to be installed in new construction projects. [ASHRAE 90.1:6.4.1.5.2]

E 503.4.25 Load Calculations. Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority (e.g., ASHRAE/ACCA Standard 183 or ASHRAE Handbook—Fundamentals). [ASHRAE 90.1:07.6.4.2.1]

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 a device and pipe segment in the critical circuit at design conditions shall be calculated. [ASHRAE 90.1:6.4.2.2]

E 503.4.36 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 503.4.3, a dwelling unit shall be permitted to be considered a single zone.

Exceptions: Independent perimeter systems that are designed to offset 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 one orientation for 50 contiguous feet (15 240 mm) or more.
2. The perimeter system heating and cooling supply is controlled by a thermostatic control(s) located within the zones(s) served by the system.

   Exterior walls are considered to have different orientations where the directions they face differ by more than 45 degrees (0.79 rad). [ASHRAE 90.1:6.4.3.1.1]

E 503.4.36.1 Dead Band. Where used to control both heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or dead band of not less than 5°F (-15°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 503.4.3.2 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 an applicable proportional band. [ASHRAE 90.1:6.4.3.2]

E 503.4.3.3 Off-Hour Controls. HVAC systems shall have the off-hour controls required by Section E 503.4.3.3(A) through Section E 503.4.3.3(D).

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 503.4.3.3(A) Automatic Shutdown. HVAC systems shall be equipped with 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 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 503.4.3.3(B) Setback Controls. Heating systems located in climate zone 2 through zone 8 shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain zone temperatures above a heating setpoint adjustable down to 55°F (13°C) or lower. Cooling systems located in climate zones 1b, 2b, and 3b shall be equipped with controls that have the capability to automatically restart and temporarily operate the system as required to maintain zone temperatures below a cooling setpoint adjustable up to 90°F (32°C) or higher or to prevent high space humidity levels.

Exception: Radiant floor and ceiling heating systems. [ASHRAE 90.1:6.4.3.3.2]

E 503.4.3.3(C) Optimum Start Controls. Individual heating and cooling air distribution systems with a total design supply air capacity exceeding 10 000 ft³/min (4.7195 m³/s), served by one or more supply fans, shall have optimum start controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint and the amount of time prior to scheduled occupancy. [ASHRAE 90.1:6.4.3.3.3]

E 503.4.3.3(D) Zone Isolation. HVAC systems serving zones that are intended to operate or be occupied non-simultaneously 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 nor include more than one floor. Each isolation area shall be equipped with isolation devices capable of automatically shutting 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 503.4.3.3(A), Automatic Shutdown. For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for a length of time while serving 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 where other zones are inoperative. [ASHRAE 90.1:6.4.3.3.4]

E 503.4.3.4 Ventilation System Controls. Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open in accordance with fire and smoke detection systems. [ASHRAE 90.1:6.4.3.4.1]

E 503.4.3.4(A) Gravity Hoods, Vents, and Ventilators. Outdoor air supply and exhaust hoods, vents, and ventilators shall be equipped with motorized dampers that will automatically shut where the spaces served are not in use.

Exceptions:
(1) Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height above grade and for buildings of any height located in climate zone 1 through zone 3.
(2) Ventilation systems serving unconditioned spaces. [ASHRAE 90.1:07.6.4.3.4.2]
E 503.4.3(B) Shutoff Damper Controls. Indoor air supply and exhaust systems shall be equipped with motorized dampers that will automatically shut off where the systems or spaces served are not in use. Ventilation outdoor air dampers shall be capable of automatically shutting off during preoccupancy building warm-up, cool down, and setback, except where ventilation reduces energy costs (e.g., night purge) or where ventilation shall be supplied to meet the requirements of this code.

Exceptions:

(1) Gravity (nonmotorized) dampers are acceptable in buildings less than three stories in height and for buildings of any height located in climate zone 1 through zone 3.

(2) Gravity (nonmotorized) dampers are acceptable in systems with a design outdoor air intake or exhaust capacity of not more than 300 ft³/min (0.142 m³/s). [ASHRAE 90.1:0.6.4.3.4.3]

(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 90.1:0.6.4.3.4.2]

E 503.4.3(C) Dampers Leakage. Where outdoor air supply and exhaust air dampers are required by Section E 503.4.3(B), they shall have a maximum leakage rate where tested in accordance with AMCA 500 as indicated in Table E 503.4.3(B).

TABLE E 503.4.3(B) MAXIMUM DAMPER LEAKAGE (cubic foot per minute per square foot) at 1.0 in. w.g.
[ASHRAE 90.1-07: TABLE 6.4.3.4.43]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>MOTORIZED</th>
<th>NONMOTORIZED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 6, 7, 8</td>
<td>4</td>
<td>Not allowed</td>
</tr>
<tr>
<td>All others</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Table E 503.4.3(B) Maximum Damper Leakage of Damper Area (cubic foot per minute per square foot) at 1.0 inch water gauge per cubic foot per minute (ft³/min) per square foot (ft²).

<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>1, 2</td>
<td>any height</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>any height</td>
<td>20</td>
</tr>
<tr>
<td>4, 5b, 5c</td>
<td>less than 3 stories</td>
<td>not allowed</td>
</tr>
<tr>
<td></td>
<td>3 or more stories</td>
<td>not allowed</td>
</tr>
<tr>
<td>5a, 6, 7, 8</td>
<td>less than 3 stories</td>
<td>not allowed</td>
</tr>
<tr>
<td></td>
<td>3 or more stories</td>
<td>not allowed</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].

E 503.4.3(D) Ventilation Fan Controls. Fans with motors greater than 0.75 hp (0.56 kW) shall have automatic controls in accordance with Section E 503.4.3(D) that are capable of shutting off fans where 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. Heated 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. [ASHRAE 90.1:6.4.3.4.5]
**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 ratio that exceeds 1500 square feet per horsepower (ft²/hp) (186.8 m²/kW) and do not utilize mechanical cooling or heating.

3. Where not permitted by the Authority Having Jurisdiction. [ASHRAE 90.1:6.4.3.4.5]

**E 503.4.3.66.6 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 can be met by the heat pump alone during both steady-state operation and setback recovery. Supplemental heater operation is permitted during outdoor coil defrost cycles.

**Exceptions:** Heat pumps whose minimum efficiency is regulated by U.S. National Appliance energy Conservation Act (NAECA) and whose HSPF rating are in accordance with the requirements shown in Table E 503.7.1(2) and includes usage of internal electric resistance heating. [ASHRAE 90.1:6.4.3.5]

**E 503.4.3.66.7 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 90.1:6.4.3.6]

**E 503.4.3.76.8 Humidification and Dehumidification.** 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 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. [ASHRAE 90.1:6.4.3.7]

**E 503.4.3.86.9 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 shutting 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 shutting 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 shutoff where the outdoor temperature is above 40°F (4°C) so that the potential for snow or ice accumulation is negligible. [ASHRAE 90.1:6.4.3.8]

**E 503.4.3.96.10 Ventilation Controls for High-Occupancy Areas.** Demand control ventilation (DCV) is required for spaces larger than 500 square feet (46.45 m²) and with a design occupancy for ventilation of more than 40 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 1200 ft³/min (0.5663 m³/s).

4. Spaces where the supply airflow rate minus a makeup or outgoing transfer air requirement is less than 1200 ft³/min (0.5663 m³/s). [ASHRAE 90.1:6.4.3.9]

**E 503.4.3.106.11 Single Zone Variable-Air-Volume Controls.** HVAC systems shall have variable airflow controls as follows in accordance with the following:

1. Air-handling and fan-coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 5.36 hp (3999 kW) shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands less than or equal to not more than 50 percent, the supply fan controls shall be able to reduce the airflow to not greater than the larger of the following:

   a. One-half of the full fan speed.

   b. The volume of outdoor air required to comply with the ventilation requirements of ASHRAE 62.1.

2. Effective January 1, 2012, air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 12.1 hp (not less than 110 000 Btu/h (32.29 kW) that serve single zones shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to not more than 50 percent, the supply fan controls shall be able to reduce the airflow to not more than the larger of the following:
E 503.4.47.12 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 503.4.47 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 be in accordance with Section E 503.4.2 and Section E 503.4.4.

E 503.4.47.1 Insulation. Insulation required by this section shall be installed in accordance with industry-accepted standards (see Informative Appendix E of ASHRAE 90.1). These requirements do 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 503.4.47.1(A) 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 503.7.1(2) and Table E 503.7.1(4).

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 503.4.1.3.

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 nonrenewable energy, fossil fuels or electricity (such as roof and condensate drains, domestic cold water supply, or natural gas piping, or refrigerant liquid piping) or where heat gain or heat loss will not increase energy usage.

4. Hot water piping between the shutoff valve and the coil, not exceeding 4 feet (1219 mm) in length, where located in conditioned spaces. Where heat gain or heat loss will not increase energy usage (such as liquid refrigerant piping).

5. Pipe unions in heating systems (steam, steam condensate, and hot water). For piping 1 inch (25 mm) or less, insulation shall not be required for strainers, control valves, and balancing valves. [ASHRAE 90.1:6.4.4.1.3]

E 503.4.47.1(C) Sensible Heating Panel Insulation. Thermally ineffective panel surfaces of sensible heating panels, including U-bends and headers, shall be insulated with not less than R-35. Adjacent building envelope insulation shall be permitted to be applied to this insulation value. [ASHRAE 90.1:6.4.4.1.4]

E 503.4.47.1(D) Radiant Floor Heating. The bottom surfaces of floor structures incorporating radiant heating shall be insulated not less than R-35. Adjacent building envelope insulation is permitted to be applied to this insulated value.

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 503.4.47.2 Ducts and Plenum Leakage. Ductwork and plenums shall be sealed in accordance with Table E 503.4.47.2(1) [Table E 503.4.47.2(2) provides definitions of seal levels], as required to be in accordance with the requirements of Section E 503.4.47.2(1) and the SMACNA HVAC Duct Construction Standard, or ASHRAE 90.1. [ASHRAE 90.1-07:6.4.4.2.1]
E 503.4.4.7(A) Duct Leakage Tests. Ductwork that is designed to operate at static pressures in excess of 3 inches water column (0.7 kPa) and ductwork located outdoors shall be leak-tested in accordance with the SMACNA 016 HVAC Air Duct Leakage Test Manual. Representative sections totaling not less than 25 percent of the total installed duct area for the designated pressure class shall be tested. Duct systems with pressure ratings in excess of exceeding 3 inches water column (0.7 kPa) shall be identified on the drawings. Sections to be tested shall be selected by the building owner or designated representative. Positive pressure leakage testing acceptable for negative pressure ductwork. The maximum permitted duct leakage shall be not more than the following calculations [ASHRAE 90.1:6.4.4.2.2]:

\[
L_{\text{max}} = C_L P 0.65
\]  

[Equation E 503.4.47.2(A)]

Where:

- \( L_{\text{max}} \) = maximum permitted leakage in \((\text{ft}^3\text{/min})/100 \text{ square feet} \) \([0.00005 \text{ m}^3/\text{s})/\text{m}^2]\) duct surface area.
- \( C_L \) = duct leakage class, \((\text{ft}^3\text{/min})/100 \text{ square feet} \) \([0.00005 \text{ m}^3/\text{s})/\text{m}^2]\) duct surface area at 1 inch water column (0.2 kPa).

Six for rectangular sheet metal, rectangular fibrous, and round flexible ducts.

Three for round/flat oval sheet metal or fibrous glass ducts.

- \( P \) = test pressure, which shall be equal to the design duct pressure class rating in inch water column (kPa) [based on ASHRAE 90.1:6.4.4.2.2]

For SI units: 1 cubic foot per minute = 0.00047 m\(^3\)/s, 1 square foot = 0.0929 m\(^2\), 1 inch water column = 0.249 kPa

<table>
<thead>
<tr>
<th>TABLE E 503.4.47.2(1)</th>
<th>MINIMUM DUCT SEAL LEVEL 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ASHRAE 90.1-07: TABLE 6.4.4.2A]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DUCT LOCATION</th>
<th>DUCT TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SUPPLY</td>
</tr>
<tr>
<td>≤2 in. w.c.(^2)</td>
<td>A</td>
</tr>
<tr>
<td>&gt;2 in. w.c.(^2)</td>
<td>B</td>
</tr>
<tr>
<td>Unconditioned spaces</td>
<td>C</td>
</tr>
<tr>
<td>Conditioned spaces</td>
<td>C</td>
</tr>
</tbody>
</table>

Notes:

1. See Table E 503.4.47.2(2) description of seal level.
2. Duct design static pressure classification.
3. Includes indirectly conditioned spaces such as return air plenums.

<table>
<thead>
<tr>
<th>TABLE E 503.4.47.2(2)</th>
<th>DUCT SEAL LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ASHRAE 90.1-07: TABLE 6.4.4.2B]</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEAL LEVEL</th>
<th>SEPARING REQUIREMENTS(^{1,2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>All transverse joints, longitudinal seams, and duct wall penetrations. 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. (See note)</td>
</tr>
<tr>
<td>B</td>
<td>All transverse joints, longitudinal seams. 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. (See note)</td>
</tr>
<tr>
<td>C</td>
<td>Transverse joints only.</td>
</tr>
</tbody>
</table>

\(^{1}\) UL 181A or UL 181B is not applicable to metal-to-metal duct joints.

\(^{2}\) Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod, or wire. Spiral lock seams in a round or flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps, and other branch connections, access door frames and jambs, duct connections to equipment, etc.
E 503.4.7.2(B) Duct Leakage Tests with Less than 3 inches Water Column. Ductwork that is designed to operate at static pressures less than 3 inches water column (0.7 kPa) located outdoors and within unconditioned space shall be leak-tested in accordance with SMACNA 016. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

E 503.4.5 Completion Requirements. Completion requirements are as described in Section E 503.6.5. [ASHRAE 90.1-02:6.4.5]

E 503.5 Prescriptive Path. Each cooling system that has a fan shall include either an air or water economizer meeting the requirements of Section E 503.5.1 through Section E 503.5.4.

Exceptions: Economizers are not required for the following systems listed below:

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. Systems that include nonparticulate air treatment in accordance with Section 6.2.1 in ASHRAE 62.1.
3. Systems 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 with applicable codes or standards. In 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 above more than 35°F (2°C) dew-point temperature to satisfy process needs. This exception shall not apply to computer rooms.
4. Systems that include a condenser heat recovery system with a minimum capacity in accordance with Sections 603.5.3 of the IAPMO Green Plumbing & Mechanical Code Supplement.
5. Systems that serve residential spaces where the system capacity is less than five times the requirement listed in Table E 503.5(1).
6. 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).
7. Systems expected to operate less than 20 hours per week.
8. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.
9. For comfort cooling where the cooling efficiency meets or exceeds is not less than the efficiency requirements in Table E 503.3.1.
10. Systems primarily serving computer rooms where in accordance with the following:
   (a) The total design cooling load of computer rooms in the building is less than 3 000 000 Btu/h (879 kW) and the building is not served by a centralized chilled water plant, or
   (b) The room total design cooling load is not more than 600 000 Btu/h (176 kW) and the building in which they are located is served by a centralized chilled water plant, or
   (c) The local water authority does not allow cooling towers, or
   (d) Less than 600 000 Btu/h (176 kW) of computer room cooling equipment capacity is being added to an existing building
11. Dedicated systems for computer rooms where a minimum of 75 percent of the design load serves 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 could present 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 E 503.5<br>MINIMUM SYSTEM SIZE FOR WHICH<br>AN ECONOMIZER IS REQUIRED<br>[ASHRAE 90.1-07: TABLE 6.5.1] |
|---|---|
| CLIMATE ZONES | COOLING CAPACITY FOR WHICH AN ECONOMIZER IS REQUIRED |
| 1a, 1b, 2a, 3a, 4a | No economizer requirement |
| 2b, 5a, 6c, 7, 8 | ≥135 000 Btu/h |
| 3b, 3c, 4b, 4c, 5b, 5c, 6b | ≥65 000 Btu/h |

For SI units: 1000 British thermal units per hour = 0.293 kW
TABLE E 503.5(1)
MINIMUM FAN-COOLING UNIT SIZE WHERE AN ECONOMIZER IS REQUIRED FOR COMFORT COOLING
[ASHRAE 90.1: TABLE 6.5.1A]

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY WHERE AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>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)
MINIMUM FAN-COOLING UNIT SIZE WHERE AN ECONOMIZER IS REQUIRED FOR COMPUTER ROOMS
[ASHRAE 90.1: TABLE 6.5.1B]

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY WHERE AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a, 1b, 2a, 3a, 4a</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2b, 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

E 503.5.1 Air Economizers. Air economizer systems shall be capable of 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 shall be capable of being sequenced 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 automatically reducing outdoor air intake to the design minimum outdoor air quantity where outdoor air intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table E 503.5.1.2(1). High-limit shutoff control settings for these control types shall be those listed in Table E 503.5.1.2(2). [ASHRAE 90.1:6.5.1.1.3]

E 503.5.1.3 Dampers. Both return air, exhaust, and outdoor air dampers shall meet the requirements of comply with Section E 503.4.3.3(D) 503.4.6 through Section E 503.4.6.12. [ASHRAE 90.1:6.5.1.1.4]

TABLE E 503.5.1.2(1)
HIGH-LIMIT SHUTOFF CONTROL OPTIONS FOR AIR ECONOMIZERS
[ASHRAE 90.1-02: TABLE 6.5.1.1.3A]

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>ALLOWED CONTROL TYPES</th>
<th>COOLING CAPACITY FOR WHICH AN ECONOMIZER IS REQUIRED PROHIBITED CONTROL TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8</td>
<td>Fixed dry bulb Differential dry bulb Electronic enthalpy* Differential enthalpy Dew-point and dry-bulb temperatures</td>
<td>Fixed enthalpy</td>
</tr>
<tr>
<td>1a, 2a, 3a, 4a</td>
<td>Fixed dry bulb Fixed enthalpy Electronic enthalpy* Differential enthalpy Dew-point and dry-bulb temperatures</td>
<td>Fixed dry bulb Differential dry bulb</td>
</tr>
<tr>
<td>All other climates</td>
<td>Fixed dry bulb Differential dry bulb Fixed enthalpy Electronic enthalpy* Differential enthalpy Dew-point and dry-bulb temperatures</td>
<td></td>
</tr>
</tbody>
</table>

* Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.
### TABLE E 503.5.1.2(2)
**HIGH-LIMIT SHUTOFF CONTROL SETTINGS FOR AIR ECONOMIZERS**

[ASHRAE 90.1-07: TABLE 6.5.1.1.3B]

<table>
<thead>
<tr>
<th>DEVICE TYPE</th>
<th>CLIMATE</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHERE):</th>
<th>EQUATION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry bulb</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8, 5a, 6a, 7a, All other zones</td>
<td>$T_{oa} &gt; 75^\circ F$</td>
<td>Outdoor air temperature exceeds 75°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$T_{oa} &gt; 70^\circ F$</td>
<td>Outdoor air temperature exceeds 70°F</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$T_{oa} &gt; 65^\circ F$</td>
<td>Outdoor air temperature exceeds 65°F</td>
</tr>
<tr>
<td>Differential dry bulb</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6a, 6b, 7, 8</td>
<td>$T_{oa} &gt; T_{Ra}$</td>
<td>Outdoor air temperature exceeds return air temperature</td>
<td></td>
</tr>
<tr>
<td>Fixed enthalpy</td>
<td>All</td>
<td></td>
<td>$h_{oa} &gt; 28$ Btu/lb</td>
<td>Outdoor air enthalpy exceeds 28 Btu/lb of dry air</td>
</tr>
<tr>
<td>Electronic enthalpy</td>
<td>All</td>
<td></td>
<td>$(T_{oa} \cdot RH_{oa}) &gt; A$</td>
<td>Outdoor air temperature/RH exceeds the “A” setpoint curve</td>
</tr>
<tr>
<td>Differential enthalpy</td>
<td>All</td>
<td></td>
<td>$h_{oa} &gt; h_{Ra}$</td>
<td>Outdoor air enthalpy exceeds return air enthalpy</td>
</tr>
<tr>
<td>Dew-point and dry-bulb temperatures</td>
<td>All</td>
<td></td>
<td>$DP_{oa} &gt; 55^\circ F$ or $T_{oa} &gt; 75^\circ F$</td>
<td>Outdoor air dry bulb exceeds 75°F or outside dew point exceeds 55°F (65 gr/lb)</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8, 1 British thermal unit per pound = 2326 J/kg, 1 grain = 0.0000648 kg

**Notes:**

1. At altitudes substantially different than sea level, the Fixed Enthalpy limit shall be set to the enthalpy value at 75°F (24°C) and 50 percent relative humidity. As an example, at approximately 6000 feet (1829 m) elevation the fixed enthalpy limit is approximately 30.7 Btu/lb (71 408 J/kg).

2. Setpoint “A” corresponds to a curve on the psychrometric chart that goes through a point at approximately 75°F (24°C) and 40 percent relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels.

### E 503.5.4 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 to avoid recirculation into the building. [ASHRAE 90.1:6.5.1.1.5]

### E 503.5.2 Water Economizers.
Water economizer systems shall be capable of cooling supply air by indirect evaporation and 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 and below.

**Exceptions:**

1. Systems in which a water economizer is used and where dehumidification requirements cannot be met using outdoor air temperatures of 50°F (10°C) dry bulb or 45°F (7°C) wet bulb satisfy 100 percent of the expected system cooling load at 45°F (7°C) dry bulb or 40°F (4°C) wet bulb. Systems primarily serving computer rooms where 100 percent of the expected system cooling load at 40°F (4°C) dry bulb or 35°F (2°C) wet bulb is achieved using evaporative water economizers.

2. Systems primarily serving computer rooms with dry cooler water economizers that provide 100 percent of the expected system cooling load at 35°F (2°C) dry bulb.

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 using evaporative water economizers. [ASHRAE 90.1:6.5.1.2.1]

### E 503.5.2.1 Maximum Pressure Drop.
Precooling coils and water-to-water heat exchangers used as part of a water 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 providing partial cooling even where additional mechanical cooling is required to meet the remainder of the cooling load.
Exceptions:

1. Direct expansion systems that include controls that reduce the quantity of outdoor air required to prevent coil frosting at the lowest step of compressor unloading, provided this lowest step is not exceeding 25 percent of the total system capacity.
2. Individual direct expansion units that have a rated cooling capacity less than 65,000 Btu/h (19 kW) and use nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling.
3. Systems in climate zones 1, 2, 3a, 4a, 5a, 5b, 6, 7, and 8. [ASHRAE 90.1-07:6.5.1.3]

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 90.1-07:6.5.1.4]

E 503.5.5 Simultaneous Heating and Cooling Limitation. Zone thermostatic controls shall be capable of operating in sequence the supply of heating and cooling energy to the zone. Such controls shall prevent the following condition provided to 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. [ASHRAE 90.1-07:6.5.2.1]

Exceptions:

1. Zones for which the volume of air that is reheated, recooled, or mixed is less than the larger of the following:
   a. Thirty percent of the A zone design peak supply rate of 30 percent.
   b. The volume of outdoor air required to be The outdoor airflow rate in accordance with the ventilation requirements of Section 6.2 of 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 reheating or recooling energy losses through a reduction in outdoor air intake.
   d. The airflow rate in accordance with applicable codes or standards, such as pressure relationships or minimum air change rates. [ASHRAE 90.1-07:6.5.2.1(a)]

2. Zones that comply with all of the following:
   a. The volume of air that is reheated, recooled, or mixed The airflow in dead band between heating and cooling does not exceed the larger of the following:
      1. Twenty percent of the A zone design peak supply rate of 20 percent.
      2. The volume of outdoor air The outdoor airflow rate required to meet in accordance with the ventilation requirements of Section 6.2 of ASHRAE 62.1 for the zone.
      3. 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 reheating or recooling energy losses through a reduction in outdoor air intake.
   b. The volume of air The airflow rate that is reheated, recooled, or mixed in peak heating demand shall be less than 50 percent of the zone design peak supply rate.
   c. Airflow between dead band and full heating or full cooling shall be modulated. [ASHRAE 90.1-07:6.5.2.1(b)]

3. Zones where special pressurization relationships, cross-contamination requirements, or code required minimum circulation rates are such that VAV systems are impractical. [ASHRAE 90.1-07:6.5.2.1(b)]

4. Laboratory exhaust systems in accordance with Section E 503.5.11.2.

5. Zones where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (including condenser heat) or site-solar energy source. [ASHRAE 90.1-07:6.5.2.1(d)]

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/exhaust air openings more than 6 feet (1829 mm) above floor shall not supply heating air more than 20°F (-7°C) above the space temperature setpoint.

Exceptions:

1. Laboratory exhaust systems in accordance with Section E 503.5.11.2.
2. During reoccupancy building warm-up and setback. [ASHRAE 90.1-07:6.5.2.1.1]
**E 503.5.5.12 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 503.5.5.12(A) through Section E 503.5.5.12(C). [ASHRAE 90.1:6.5.2.2]

**E 503.5.5.12 (A) 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 503.5.5.12 (B) Two-Pipe Changeover System.** Systems that use a common distribution system to supply both heated and chilled water are acceptable provided the following requirements are met:

1. The system is designed to allow a dead band between changeover from one mode to the other of not less than 15°F (-9°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 (-1°C) apart. [ASHRAE 90.1:6.5.2.2.2]

**E 503.5.5.12 (C) 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 providing a heat pump water supply temperature dead band of not less than 20°F (-7°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 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 tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass heat pump water flow around the tower. Where an open-circuit 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 (-7°C) shall be permitted. [ASHRAE 90.1:6.5.2.2.3]

**E 503.5.5.23 Dehumidification.** Where humidistic 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 reducing supply air volume to 50 percent or less of the design airflow rate or the minimum outdoor air ventilation rate specified 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 80 000 Btu/h (23.4 kW) and is capable of unloading to 50 percent capacity before simultaneous heating and cooling takes place.
3. The individual mechanical cooling unit has a design cooling capacity of 40 000 Btu/h (11.7 kW) or less. 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, computer rooms, museums, surgical suites; and buildings with refrigerating systems, such as supermarkets, refrigerated warehouses, and ice arenas. This exception shall not apply to computer rooms, also applies to other applications for which fan volume controls in accordance with Exception (1) are proven to be impractical to the enforcement agency.
5. Not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (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 90.1:07:6.5.2.3]

**E 503.5.5.34 Humidification.** Systems with hydronic cooling and humidification systems designed to maintain inside humidity at a dew-point temperature greater than 35°F (2°C) shall use a water economizer where an economizer is required by Section E 503.5. [ASHRAE 90.1:6.5.2.4]

**E 503.5.6 Air System Design and Control.** Each HVAC system having a total fan system motor nameplate horsepower (hp) exceeding 5 hp (3.7 kW) shall meet be in accordance with the provisions of Section E 503.5.6.1 and Section E 503.5.6.24. [ASHRAE 90.1:07:6.5.3]
**E 503.5.6.1 Fan System Power Limitation.** Each HVAC system 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. [ASHRAE 90.1-07:6.5.3.1.1]

**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 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(A) Motor Nameplate Horsepower.** For each fan, the selected fan motor shall be not larger than the first available motor size greater than the brake horsepower (bhp) (kW). The fan brake horsepower shall be indicated on the design documents to allow for compliance verification by the code official.

**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 with 30 percent of the bhp (kW), the next larger nameplate motor size shall be selected. [ASHRAE 90.1:6.5.3.1.2]

**E 503.5.6.2 VAV Fan Control (Including Systems Using Series Fan Power Boxes).** Individual VAV fans with motors 10 hp (7.5 kW) and larger shall meet one of the following:

1. The fan shall be driven by a mechanical or electrical variable-speed drive.
2. The fan shall be a vane-axial fan with variable-pitch blades.
3. The fan shall have other controls and devices that will result in fan motor demand of not more than 30 percent of design wattage at 50 percent of design air volume where static pressure setpoint equals one-third of the total design static pressure, based on manufacturer’s certified fan data. [ASHRAE 90.1:6.5.3.2.1]

**E 503.5.6.2(A) Static Pressure Sensor Location.** Static pressure sensors used to control VAV fans shall be placed in a position such that the controller setpoint is not greater than one-third the total design fan static pressure, except for systems with zone reset control in accordance with Section E 503.5.6.2(B). Where this results in the sensor being located downstream of major duct splits, multiple sensors shall be installed in each major branch to ensure that static pressure is maintained in each. [ASHRAE 90.1:6.5.3.2.2]

**TABLE E 503.5.6.1(1) FAN POWER LIMITATION* [ASHRAE 90.1: TABLE 6.5.3.1.1A]**

<table>
<thead>
<tr>
<th>OPTION</th>
<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>
<td>( hp \leq CFM_S \times 0.0015 )</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>
<td>( bhp \leq CFM_S \times 0.0013 + A )</td>
</tr>
</tbody>
</table>

For SI units: 1 horsepower = 0.746 kW, 1 cubic foot per minute = 0.00047 m³/s

*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)

\( A \) = sum of \( PD \times CFM_D / 4131 \)

Where:

\( PD \) = 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
TABLE E 503.5.6.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT
[ASHRAE 90.1: TABLE 6.5.3.1.1B]

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>CREDITS</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully ducted return, exhaust, or both air systems</td>
<td>0.5 in. w.c. (2.15 in w.c. for laboratory and vivarium systems)</td>
<td></td>
</tr>
<tr>
<td>Return, exhaust, or both airflow control devices</td>
<td>0.5 in. w.c.</td>
<td></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>
<td></td>
</tr>
<tr>
<td>Particulate Filtration Credit: MERV 9 through 12</td>
<td>0.5 in. w.c.</td>
<td></td>
</tr>
<tr>
<td>Particulate Filtration Credit: MERV 13 through 15</td>
<td>0.9 in. w.c.</td>
<td></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>
<td></td>
</tr>
<tr>
<td>Carbon and other gas-phase air cleaners</td>
<td>Clean filter pressure drop at fan system design condition</td>
<td></td>
</tr>
<tr>
<td>Heat recovery device, Biosafety cabinet</td>
<td>Pressure drop of device at fan system design condition</td>
<td></td>
</tr>
<tr>
<td>Energy recovery device, other than coil runaround loop</td>
<td>(2.2 x energy recovery effectiveness)</td>
<td>0.5 in. w.c. for each airstream</td>
</tr>
<tr>
<td>Coil runaround loop</td>
<td>0.6 in. w.c. for each airstream</td>
<td></td>
</tr>
<tr>
<td>Evaporative humidifier/cooler in series with another cooling coil</td>
<td>Pressure drop of device at fan system design condition</td>
<td></td>
</tr>
<tr>
<td>Sound Attenuation Section</td>
<td>0.15 in. w.c.</td>
<td></td>
</tr>
<tr>
<td>Exhaust system serving fume hoods</td>
<td>0.35 in. w.c.</td>
<td></td>
</tr>
<tr>
<td>Laboratory and vivarium exhaust systems in high-rise buildings</td>
<td>0.25 in. w.c./100 ft of vertical duct exceeding 75 ft</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1 inch water column = 0.249 kPa, 1 foot = 304.8 mm

**E 503.5.6.2(B) Setpoint Reset.** For systems with DDC of individual zone boxes reporting to the central control panel, static pressure setpoint shall be reset based on the zone requiring the most pressure (e.g., the setpoint is reset lower until one zone damper is nearly wide open). [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 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.

**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 required to have the exhaust air energy recovery in accordance with Section E 503.5.10.
(3) 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 design supply-air temperature and the design room air temperature. Controls that adjust the reset based on zone humidity shall be permitted. Zones which 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 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 or site solar energy sources. [ASHRAE 90.1:6.5.3.4]
E 503.5.7 Hydronic System Design and Control. HVAC hydronic systems having a total pump system power exceeding 10 hp (7.5 kW) shall be in accordance with Section E 503.5.7.1 through Section E 503.5.7.4. [ASHRAE 90.1-07:6.5.4]

E 503.5.7.1 Hydronic Variable Flow Systems. HVAC pumping systems having a total pump system power exceeding 10 hp (7.5 kW) that include 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 reducing pump flow rates to 50 percent or less of the design flow rate. Individual chilled water pumps serving variable flow systems having a pump head exceeding 100 feet (299 kPa) and motors exceeding 50 hp (37.3 kW) shall have controls, devices or both (such as variable speed control) 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 be in accordance with this section, and DDC controls are used, the setpoint shall be reset downward based on valve positions until one valve is nearly wide open.

Exceptions:
(1) Systems where the minimum flow is less than the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system, such as chillers, and where total pump system power is 75 hp (55.9 kW) or less.
(2) Systems that include not more than three control valves. [ASHRAE 90.1-07:6.5.4.1]

E 503.5.7.2 Pump Isolation. Where a chilled-water plant includes more than one chiller, provisions shall be made so that the flow in the chiller plant is capable of being automatically reduced, correspondingly, where a chiller is shut down. Chillers referred to in this section, piped in series for the purpose of increased temperature differential, shall be considered as one chiller.

Where a boiler plant includes more than one boiler, provisions shall be made so that the flow in the boiler plant is capable of being automatically reduced, correspondingly, where a boiler is shut down. [ASHRAE 90.1-07:6.5.4.2]

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.

Exceptions:
(1) Where the supply temperature reset controls cannot be implemented without causing improper operation of heating, cooling, humidifying, or dehumidifying systems.
(2) Hydronic systems, such as those required by Section E 503.5.7.1 that use variable flow to reduce pumping energy. [ASHRAE 90.1-07:6.5.4.3]

E 503.5.7.4 Hydronic (Water Loop) Heat Pump Systems. Each hydronic heat pumps and water-cooled unitary air-conditioners shall have a two-position automatic valve interlocked to shut off water flow where the compressor is off.

Exception: Units employing water economizers. [ASHRAE 90.1-07:6.5.4.4.1]

E 503.5.7.4(A) 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 pump motor demand of not more than 30 percent of design wattage at 50 percent of design water flow. [ASHRAE 90.1-07:6.5.4.4.2]

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 segment does not exceed the values listed in Table E 503.5.7.5 for the appropriate total annual hours of operation. Pipe size selections for systems that operate under variable flow conditions, such as 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. [ASHRAE 90.1-07:6.5.4.5]

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 is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during 30 percent or more of operating hours.
(2) Piping systems that have not more than the total pressure drop of the same system constructed with standard weight steel pipe with piping and fittings sized in accordance with Table E 503.5.7.5.
TABLE E 503.5.7.5
PIPING SYSTEM DESIGN MAXIMUM FLOW RATE (gallons per minute)
[ASHRAE 90.1: TABLE 6.5.4.5]

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE INCH</th>
<th>OPERATING HOURS/YEAR</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;2000 HOURS/YEAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2½</td>
<td>120</td>
<td>180</td>
<td>85</td>
<td>130</td>
<td>68</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>180</td>
<td>270</td>
<td>140</td>
<td>210</td>
<td>110</td>
<td>170</td>
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<tr>
<td></td>
<td>4</td>
<td>350</td>
<td>530</td>
<td>260</td>
<td>400</td>
<td>210</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>410</td>
<td>620</td>
<td>310</td>
<td>470</td>
<td>250</td>
<td>370</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>740</td>
<td>1100</td>
<td>570</td>
<td>860</td>
<td>440</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>1200</td>
<td>1800</td>
<td>900</td>
<td>1400</td>
<td>700</td>
<td>1100</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1800</td>
<td>2700</td>
<td>1300</td>
<td>2000</td>
<td>1000</td>
<td>1600</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2500</td>
<td>3800</td>
<td>1900</td>
<td>2900</td>
<td>1500</td>
<td>2300</td>
</tr>
<tr>
<td>Maximum velocity for pipes over 12 inch size</td>
<td>8.5 ft/s</td>
<td>13.0 ft/s</td>
<td>6.5 ft/s</td>
<td>9.5 ft/s</td>
<td>5.0 ft/s</td>
<td>7.5 ft/s</td>
<td></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 mm

E 503.5.8 Heat Rejection Equipment. Section E 503.5.8 and Section E 503.5.9 apply to heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open 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. Each fan powered by a motor of 7.5 hp (5.59 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less and shall have controls that automatically change 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.
(2) Condenser fans serving flooded condensers.
(3) Installations located in climate zone 1 and zone 2.
(4) Up to one-third of the fans on a condenser or tower with multiple fans, where the lead fans are in accordance with the speed control requirement. [ASHRAE 90.1:6.5.5.2]

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 meet the energy efficiency requirement for axial fan open-circuit cooling towers listed in Table E 503.7.1(7).

Exception: Open-circuit cooling towers that are ducted (inlet or discharge) or require external sound attenuation. [ASHRAE 90.1:6.5.5.3]

E 503.5.10 Exhaust Air Energy Recovery. Individual fan systems that have both a design supply air capacity of 5000 ft³/min (2.3597 m³/s) or greater and have an outdoor air supply of not less than 70 percent or greater of the design supply air quantity shall have an energy recovery system with not less than 50 percent recovery effectiveness. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 50 percent of the difference between the outdoor air and return air at design conditions. Provision shall be made to bypass or control the heat recovery system to permit air economizer operation in accordance with Section E 503.5.1 through Section 503.5.4. A fan system shall have an energy recovery system where the system's supply air flow rate exceeds the value listed in Table E 503.5.10 based on the climate zone and percentage of outdoor air flow rate at design conditions. Energy recovery systems required by this section shall have 50 percent or more recovery effectiveness. Fifty percent energy recovery effectiveness shall be the change in the enthalpy of the outdoor air supply equal to 50 percent of the difference between the outdoor air and return 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 meeting Section E 503.5.11.43.
2. Systems serving spaces that are not cooled and that are heated to less than 60°F (16°C).
3. Systems exhausting toxic, flammable, paint, corrosive fumes, or dust.
4. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.
5. Where more than 60 percent of the outdoor air heating energy is provided from site-recovered or site-solar energy.
6. Heating systems in climate zone 1 through and zone 2.
7. Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8.
8. Where the largest exhaust source of air exhausted at a single location at the building exterior is less than 75 percent of the design outdoor airflow rate.
9. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
10. Systems expected to operate 20 hours or less per week at the outdoor air percentage in accordance with Table E 503.5.10. [ASHRAE 90.1-07:6.5.6.1]

**TABLE E 503.5.10 ENERGY RECOVERY REQUIREMENT**

[ASHRAE 90.1: TABLE 6.5.6.1]

<table>
<thead>
<tr>
<th>ZONE</th>
<th>PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥30% and &lt;40%</td>
</tr>
<tr>
<td>3B, 3C, 4B, 4C, 5B</td>
<td>NR</td>
</tr>
<tr>
<td>1B, 2B, 5C</td>
<td>NR</td>
</tr>
<tr>
<td>6B</td>
<td>≥11000</td>
</tr>
<tr>
<td>1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥5500</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥2500</td>
</tr>
</tbody>
</table>

For SI units: 1 cubic foot per minute = 0.00047 m³/s
*NR = No Requirement

**E 503.5.11 Exhaust Hoods.** Individual kitchen exhaust hoods larger than 5000 ft³/min (2.3597 m³/s) shall be provided with makeup air sized for not less than 50 percent of exhaust air volume that is unheated or heated to not more than 60°F (16°C) and uncooled or cooled without the use of mechanical cooling.

Exceptions:

1. Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems.
2. Certified grease extractor hoods that require a face velocity not greater than 60 feet per minute (ft/min) (0.03 m/s). [ASHRAE 90.1-07:6.5.7.1]

**E 503.5.11.1 Fume Hoods.** Buildings with fume hood systems having a total exhaust rate greater than 15000 ft³/min (7.0792 m³/s) shall include not less than one of the following features:

1. VAV hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
2. Direct makeup (auxiliary) air supply equal to not less than 75 percent of the exhaust rate, heated not warmer than 2°F (1°C) below room setpoint, cooled to not cooler than 3°F (1°C) above room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Heat recovery systems to precondition makeup air from fume hood exhaust in accordance with Section E 503.5.10, without using any exception. [ASHRAE 90.1-07:6.5.7.2]

**E 503.5.10.1 Heat Recovery for Service Water Heating.** Heat recovery shall comply with Section E 503.5.10.1(A) and Section E 503.5.10.1(B)

**E 503.5.10.1(A) 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(B) 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 is more than 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 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 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 90.1:6.5.7.1.1]

Conditioned supply air delivered to a space with a kitchen hood 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 hood exhaust flow minus the available transfer air from adjacent spaces. Available transfer air is that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces. [ASHRAE 90.1:6.5.7.1.2]

E 503.5.11.2 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 90.1:6.5.7.1.3]

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>LIGHT DUTY EQUIPMENT</th>
<th>MEDIUM DUTY EQUIPMENT</th>
<th>HEAVY DUTY EQUIPMENT</th>
<th>EXTRA HEAVY DUTY EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted canopy</td>
<td>140</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Single island</td>
<td>280</td>
<td>350</td>
<td>420</td>
<td>490</td>
</tr>
<tr>
<td>Double Island (per side)</td>
<td>175</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>175</td>
<td>175</td>
<td>Not allowed</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Backshelf/ Pass-over</td>
<td>210</td>
<td>210</td>
<td>280</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1 cubic foot per minute = 0.00047 m³/s

E 503.5.11.2(A) Kitchen or Dining Facility. Where a kitchen or dining facility has a total kitchen hood exhaust airflow rate more than 5000 ft³/min (2,3957 m³/s) one of the following shall be provided:

(1) Fifty percent or more of replacement air is transfer air that would otherwise be exhausted.

(2) Demand ventilation system(s) provide 75 percent or more of the exhaust air. Such systems are capable of providing 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 with a sensible heat recovery effectiveness of 40 percent or more on 50 percent or more of the total exhaust airflow. [ASHRAE 90.1:6.5.7.1.4]

E 503.5.11.2(B) 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(A), additional performance testing shall be provided to demonstrate proper capture and containment at minimum airflow. [ASHRAE 90.1:6.5.7.1.5]
**E 503.5.11.3 Laboratory Exhaust Systems.** Buildings with laboratory exhaust systems having a total exhaust rate of 5000 ft$^3$/min (2.3597 m$^3$/s) or more shall include at least one of the following features:

1. VAV laboratory exhaust and room supply systems capable of reducing exhaust air flow rates, makeup air flow rates, or both shall incorporate a heat recovery system to precondition makeup air from laboratory exhaust 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.
   - \( B \) = Percentage sensible recovery effectiveness.
   - \( E \) = 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 required to have minimum circulation rates to be in accordance with the applicable codes or standards shall be capable of reducing zone exhaust and makeup air flow rates to the regulated minimum circulation values, or the minimum required to maintain pressurization relationship requirements. Nonregulated zones shall be capable of reducing exhaust and makeup air flow 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 rate, heated not more than 2°F (-17°C) below room setpoint, cooled to not less than 3°F (-16°C) above room setpoint, no humidification is added, and no simultaneous heating and cooling are used for dehumidification control. [ASHRAE 90.1:6.5.7.2]

**E 503.5.12 Radiant Heating Systems.** Radiant heating shall be used where 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 enclosed space heating shall be in accordance with the governing provisions of 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.

**Exception:** Unitary packaged systems with cooling capacities not greater than 90 000 Btu/h (26.4 kW). [ASHRAE 90.1:6.5.9]

<table>
<thead>
<tr>
<th>RATED CAPACITY</th>
<th>MAXIMUM HOT GAS BYPASS CAPACITY (percent of total capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤240 000 Btu/h</td>
<td>50%</td>
</tr>
<tr>
<td>&gt;240 000 Btu/h</td>
<td>25%</td>
</tr>
</tbody>
</table>

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

**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. [ASHRAE 90.1:6.7.1]

**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 Section E 503.6.3.1 and Section E 503.6.5.2. [ASHRAE 90.1:4.2.2.3]
E 503.6.1 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. [ASHRAE 90.1:6.7.2]

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. The following requirements 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 (see Informative Appendix E of ASHRAE 90.1) 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 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 setpoints. [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(A) 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(B) 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(A) 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 and duct insulation shall comply with Section E 503.7.2.

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(11).

E 503.7.2 Duct Insulation Tables. Duct insulation shall comply with Table E 503.7.2(1) through Table E 503.7.2(4).

E 504.0 Solar Energy Systems.

E 504.1 General. Solar energy systems shall be installed in accordance with the Uniform Solar Energy Code.
E 505.0 Geothermal Systems.

E 505.1 General. 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 505.1.4.

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, and the applicable requirements for hydronic piping systems of this code.

E 505.1.2 Pipe Materials. Unless otherwise approved by the Authority Having Jurisdiction, underground and submerged pipe used in geothermal systems shall be polyethylene manufactured from resin compound PE 3408 or PE 4710 that complies with ASTM D3350 with a cell classification of 345564 or 345434. Pipe shall comply with ASTM Standard D3035 or CSA Standard B137.1. Polyethylene fittings shall comply with the requirements in ASTM D3261, ASTM D2683, ASTM F1055 or CSA Standard B137.1. Joints and connections of underground and submerged polyethylene piping shall be heat fused or electrofused. All other pipe and fittings shall comply with the applicable requirements for hydronic piping systems in the mechanical code.

E 505.1.3 Marking. Geothermal piping systems shall have uppercase lettering, with the words “GEOTHERMAL” or “GEO.” Additional, the piping shall not be marked with the word “potable,” or the letters “P” or “PW.”

E 505.1.4 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.

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY1</th>
<th>TEST PROCEDURE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single Package</td>
<td>13.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Through-the-wall, air cooled</td>
<td>≤30 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>10.9 SEER (before 1/1/2010) 12.0 SEER (as of 1/1/2010)</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single Package</td>
<td>10.6 SEER (before 1/1/2010) 12.0 SEER (as of 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>10.3 EER (before 1/1/2010) 11.2 EER (as of 1/1/2010) 11.4 IEER (as of 1/1/2010)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.1 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010) 11.2 IEER (as of 1/1/2010)</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>Split system and single package</td>
<td>9.7 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010) 11.2 IEER (as of 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>9.5 EER (before 1/1/2010) 10.8 EER (as of 1/1/2010) 11.0 IEER (as of 1/1/2010)</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>Split system and single package</td>
<td>9.5 EER (before 1/1/2010) 9.7 IPLV (before 1/1/2010) 10.1 IEER (as of 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>9.3 EER (before 1/1/2010) 9.8 EER (as of 1/1/2010) 9.5 IPLV (before 1/1/2010) 9.9 IEER (as of 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>9.2 EER (before 1/1/2010) 9.7 EER (as of 1/1/2010) 9.4 IPLV (before 1/1/2010) 9.8 IEER (as of 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>9.5 EER (as of 1/1/2010) 9.2 IPLV (before 1/1/2010) 9.6 IEER (as of 1/1/2010)</td>
<td></td>
</tr>
</tbody>
</table>

TABLE E 503.7.1(1) ELECTRONICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS MINIMUM EFFICIENCY REQUIREMENTS [ASHRAE 90.1-07: TABLE 6.8.1A]
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY¹</th>
<th>TEST PROCEDURE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, evaporatively</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split system and single package</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>Split system and single package</td>
<td>11.5 EER (before 6/1/2011) 12.1 EER (as of 6/1/2011) 11.7 IEER (as of 1/1/2010 before 6/1/2011) 12.3 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Split system and single package</td>
<td>11.3 EER (before 6/1/2011) 11.9 EER (as of 6/1/2011) 11.5 IEER (as of 1/1/2010 before 6/1/2011) 12.1 IEER (as of 6/1/2011)</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>Split system and single package</td>
<td>11.0 EER (before 6/1/2011) 12.5 EER (as of 6/1/2011) 11.2 IEER (as of 1/1/2010 before 6/1/2011) 12.5 IEER (as of 6/1/2011)</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>Split system and single package</td>
<td>11.0 EER (before 6/1/2011) 12.4 EER (as of 6/1/2011) 10.3 IPLV (before 1/1/2010) 11.1 IEER (as of 1/1/2010 before 6/1/2011) 12.6 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥760 000 Btu/h</td>
<td>Electric Resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER (before 6/1/2011) 12.2 EER (as of 6/1/2011) 11.1 IEER (before 6/1/2011) 12.4 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011) 12.0 EER (as of 6/1/2011) 10.9 IEER (before 6/1/2011) 12.2 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, evaporatively</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split system and single package</td>
<td>12.1 EER 12.3 IEER</td>
<td>AHRI 210/240</td>
</tr>
</tbody>
</table>

¹ EER: Energy Efficiency Ratio
² IEER: International Efficiency Ratio

AHRI 210/240: American Heating, Refrigeration, and Air Conditioning Institute
AHRI 340/360: American Heating, Refrigeration, and Air Conditioning Institute
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY$^1$</th>
<th>TEST PROCEDURE$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, evaporatively cooled</td>
<td>$\geq 65\ 000\ \text{Btu/h}$ and $&lt;135\ 000\ \text{Btu/h}$</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.5 EER (before 6/1/2011) 12.1 EER (as of 6/1/2011) 11.7 IEER (before 6/1/2011) 12.3 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>11.3 EER (before 6/1/2011) 11.9 EER (as of 6/2/2011) 11.5 IEER (before 6/1/2011) 12.1 IEER (as of 6/1/2011)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\geq 135\ 000\ \text{Btu/h}$ and $&lt;240\ 000\ \text{Btu/h}$</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER (before 6/1/2011) 12.0 EER (as of 6/1/2011) 11.2 IEER (before 6/1/2011) 12.2 IEER (as of 6/1/2011)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011) 11.8 EER (as of 6/1/2011) 11.0 IEER (before 6/1/2011) 12.0 IEER (as of 6/1/2011)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\geq 240\ 000\ \text{Btu/h}$ and $&lt;760\ 000\ \text{Btu/h}$</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER (before 6/1/2011) 11.9 EER (as of 6/1/2011) 11.1 IEER (before 6/1/2011) 12.1 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011) 12.2 EER (as of 6/1/2011) 10.9 IEER (before 6/1/2011) 11.9 IEER (as of 6/1/2011)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>$\geq 760\ 000\ \text{Btu/h}$</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER (before 6/1/2011) 11.7 EER (as of 6/1/2011) 11.1 IEER (before 6/1/2011) 11.9 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011) 11.5 EER (as of 6/1/2011) 10.9 IEER (before 6/1/2011) 11.7 IEER (as of 6/1/2011)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing units, air cooled</td>
<td>$\geq 135\ 000\ \text{Btu/h}$</td>
<td>–</td>
<td>–</td>
<td>10.1 EER (before 6/1/2011) 10.5 EER (as of 6/1/2011) 10.4 IEER (before 6/1/2011) 11.8 IEER (as of 6/1/2011)</td>
<td>AHRI 365</td>
</tr>
<tr>
<td>Condensing units, water or evaporatively cooled</td>
<td>$\geq 135\ 000\ \text{Btu/h}$</td>
<td>–</td>
<td>–</td>
<td>13.1 EER (before 6/1/2011) 13.5 EER (as of 6/1/2011) 13.6 IEER (before 6/1/2011) 14.0 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
</tbody>
</table>

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

Notes:
1 IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
2 Section 12 of ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.
3 Single-phase, air-cooled air conditioners less than 65 000 Btu/h (19 kW) are regulated by NAECA. SEER values are those set by NAECA.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR 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</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≤30 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>10.6 SEER (before 1/1/2010)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>Through-the-wall (air cooled, cooling mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric resistance (or none)</td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>Split system and single package</td>
<td>11.0 EER (before 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>All</td>
<td>Split system and single package</td>
<td>10.4 EER (as of 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>All</td>
<td>Split system and single package</td>
<td>8.8 EER (before 1/1/2010)</td>
<td></td>
</tr>
<tr>
<td>Water source (cooling mode)</td>
<td>&lt;17 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>11.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td>≥17 000 Btu/h and &lt;65 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.0 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.0 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Groundwater source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>16.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Ground source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>77°F entering water</td>
<td>13.4 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Water source water to water (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>Groundwater source water to water (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>Ground source brine to water (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>
</tbody>
</table>
For SI units: 1000 British thermal units per hour = 0.293 kW, °C = (°F-32)/1.8

Notes:
1 IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
2 Section 12 of ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.
3 Single-phase air-cooled heat pumps less than 65 000 Btu/h (19 kW) are regulated by NAEC, SEER, and HSPF values are those set by NAEC.

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (heating mode)</td>
<td>&lt;65 000 Btu/h (^1) (cooling capacity)</td>
<td>–</td>
<td>Split system</td>
<td>7.7 HSPF (\text{before 1/23/2006})</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall, (air cooled, heating mode)</td>
<td>≤30 000 Btu/h (^1) (cooling capacity)</td>
<td>–</td>
<td>Split system</td>
<td>7.1 HSPF (\text{before 1/23/2010}), 7.4 HSPF (\text{as of 1/23/2010})</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>Single package</td>
<td>7.7 HSPF (\text{before 1/23/2006}), 7.4 HSPF (\text{as of 1/23/2010})</td>
<td></td>
<td></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</td>
<td>6.8 HSPF</td>
<td>–</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>Single package</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td>65 000 Btu/h and &lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.2 COP (\text{before 1/1/2010}), 3.3 COP (\text{as of 1/1/2010})</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>–</td>
<td>17°F db/15°F wb outdoor air</td>
<td>2.2 COP (\text{before 1/1/2010}), 2.25 COP (\text{as of 1/1/2010})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>–</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.1 COP (\text{before 1/1/2010}), 3.2 COP (\text{as of 1/1/2010})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>–</td>
<td>17°F db/15°F wb outdoor air</td>
<td>2.05 COP (\text{as of 1/1/2010}), 2.0 COP (\text{before 1/1/2010})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water source (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>68°F entering water</td>
<td>4.2 COP</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Groundwater source (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>50°F entering water</td>
<td>3.6 COP</td>
<td></td>
</tr>
<tr>
<td>Ground Source (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>32°F entering water</td>
<td>3.1 COP</td>
<td></td>
</tr>
<tr>
<td>Water source water to water (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>68°F entering water</td>
<td>3.7 COP</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Groundwater source water to water (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>50°F entering water</td>
<td>3.1 COP</td>
<td></td>
</tr>
<tr>
<td>Ground source brine to water (heating mode)</td>
<td>&lt;135 000 Btu/h (cooling capacity)</td>
<td>–</td>
<td>32°F entering water</td>
<td>2.5 COP</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 IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
2 Section 12 of ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.
3 Single-phase air-cooled heat pumps less than 65 000 Btu/h (19 kW) are regulated by NAEC, SEER, and HSPF values are those set by NAEC.
# TABLE E 503.7.1(3)
## WATER CHILLING PACKAGES - EFFICIENCY REQUIREMENTS

[ASHRAE 90.1: TABLE 6.8.1C]

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>BEFORE 1/1/2010</th>
<th>AS OF 1/1/2010</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>FULL LOAD</td>
<td>IPLV</td>
<td>FULL LOAD</td>
</tr>
<tr>
<td>Air-Cooled Chillers</td>
<td>&lt;150 tons</td>
<td>EER</td>
<td>≥0.562</td>
<td>10.116</td>
<td>≥9.562</td>
</tr>
<tr>
<td></td>
<td>≥150 tons</td>
<td>EER</td>
<td>≥0.562</td>
<td>10.116</td>
<td>≥9.562</td>
</tr>
<tr>
<td>Air cooled, without condenser,</td>
<td>All capacities</td>
<td>EER</td>
<td>≥10.586</td>
<td>11.782</td>
<td>Air-cooled chillers without condensers shall be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.</td>
</tr>
<tr>
<td>electrically operated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cooled, electrically operated,</td>
<td>All capacities</td>
<td>kW/ton</td>
<td>≤0.827</td>
<td>≤0.696</td>
<td>Reciprocating units shall comply with water cooled positive displacement efficiency requirements.</td>
</tr>
<tr>
<td>reciprocating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cooled, electrically operated,</td>
<td>&lt;75 tons</td>
<td>kW/ton</td>
<td>≤0.790</td>
<td>≤0.676</td>
<td>≤0.780</td>
</tr>
<tr>
<td>positive displacement</td>
<td>&gt;75 tons and</td>
<td>kW/ton</td>
<td>≤0.790</td>
<td>≤0.676</td>
<td>≤0.775</td>
</tr>
<tr>
<td>&lt;150 tons</td>
<td>&gt;150 tons and</td>
<td>kW/ton</td>
<td>≤0.717</td>
<td>≤0.627</td>
<td>≤0.680</td>
</tr>
<tr>
<td>&lt;300 tons</td>
<td>&gt;300 tons</td>
<td>kW/ton</td>
<td>≤0.639</td>
<td>≤0.541</td>
<td>≤0.620</td>
</tr>
<tr>
<td>Water cooled, electrically operated,</td>
<td>&lt;150 tons</td>
<td>kW/ton</td>
<td>≤0.703</td>
<td>≤0.660</td>
<td>≤0.634</td>
</tr>
<tr>
<td>centrifugal</td>
<td>&gt;150 tons and</td>
<td>kW/ton</td>
<td>≤0.634</td>
<td>≤0.634</td>
<td>≤0.634</td>
</tr>
<tr>
<td>&lt;300 tons</td>
<td>&gt;300 tons</td>
<td>kW/ton</td>
<td>≤0.576</td>
<td>≤0.549</td>
<td>≤0.576</td>
</tr>
<tr>
<td>Water cooled, electrically operated,</td>
<td>&gt;600 tons</td>
<td>kW/ton</td>
<td>≤0.576</td>
<td>≤0.549</td>
<td>≤0.570</td>
</tr>
<tr>
<td>absorption single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.600</td>
<td>NR^5</td>
<td>≥0.600</td>
</tr>
<tr>
<td>absorption single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.700</td>
<td>NR^5</td>
<td>≥0.700</td>
</tr>
<tr>
<td>absorption double effect, indirect-</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000</td>
<td>≥1.050</td>
<td>≥1.000</td>
</tr>
<tr>
<td>fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000</td>
<td>≥1.000</td>
<td>≥1.000</td>
</tr>
</tbody>
</table>

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW

**Notes:**

1. The centrifugal chiller equipment requirements after adjustment in accordance with Section E 503.4.1 shall not apply to chillers with design leaving fluid evaporator temperature less than 45°F (7.2°C) or 36°F (2°C). The requirements shall not apply to positive displacement chillers with design leaving fluid temperatures 32°F (0°C) or less. The requirements shall not apply to absorption chillers with design leaving fluid temperatures less than 40°F (4°C).

2. Section 12 of ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

3. Compliance with this supplement can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or Path B.

4. NA means that this requirement is not applicable and cannot be used for compliance.

5. NR means that there are no minimum requirements for this category.
**TABLE 503.7.1(4)**

**ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL SINGLE-PACKAGED VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS, AND ROOM AIR CONDITIONER HEAT PUMPS - MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1-07: TABLE 6.8.1D]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PTAC (cooling mode)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.5 - (0.213 x Cap/1000)^3 EER(before 10/8/2012) 13.8 - (0.300 x Cap/1000)^3</td>
</tr>
<tr>
<td>Nonstandard Size^2</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.9 - (0.213 x Cap/1000)^3 EER</td>
</tr>
<tr>
<td><strong>PTHP (cooling mode)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.3 - (0.213 x Cap/1000)^3 EER(before 10/8/2012) 14.0 - (0.300 x Cap/1000)^3 EER (as of 10/8/2012)</td>
</tr>
<tr>
<td>Nonstandard Size^2</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.8 - (0.213 x Cap/1000)^3 EER</td>
</tr>
<tr>
<td><strong>PTHP (heating mode)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.2 - (0.026 x Cap/1000)^3 COP_H (before 10/8/2012) 3.7 - (0.052 x Cap/1000)^3 COP_H (as of 10/8/2012)</td>
</tr>
<tr>
<td>Nonstandard Size^2</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>SPAC (cooling mode)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and ≤135 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.9 EER</td>
<td></td>
</tr>
<tr>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.6 EER</td>
<td></td>
</tr>
<tr>
<td><strong>SPVHP (cooling mode)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.9 EER</td>
<td></td>
</tr>
<tr>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.6 EER</td>
<td></td>
</tr>
<tr>
<td><strong>SPVHP (heating mode)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COP</td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COP</td>
<td></td>
</tr>
<tr>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>2.9 COP</td>
<td></td>
</tr>
<tr>
<td><strong>Room air conditioners,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with louvered sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;6000 Btu/h</td>
<td>–</td>
<td></td>
<td>9.7 SEER</td>
</tr>
<tr>
<td>≥6000 Btu/h and &lt;8000 Btu/h</td>
<td>–</td>
<td></td>
<td>9.7 SEER</td>
</tr>
<tr>
<td>≥8000 Btu/h and &lt;14 000 Btu/h</td>
<td>–</td>
<td></td>
<td>9.8 EER</td>
</tr>
<tr>
<td>≥14 000 Btu/h and &lt;20 000 Btu/h</td>
<td>–</td>
<td></td>
<td>9.7 SEER</td>
</tr>
<tr>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td></td>
<td>8.5 EER</td>
</tr>
<tr>
<td>&lt;8000 Btu/h</td>
<td>–</td>
<td></td>
<td>9.0 EER</td>
</tr>
<tr>
<td><strong>Room air conditioners,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without louvered sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥8000 Btu/h and &lt;20 000 Btu/h</td>
<td>–</td>
<td></td>
<td>8.5 EER</td>
</tr>
<tr>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td></td>
<td>8.5 EER</td>
</tr>
<tr>
<td><strong>Room air-conditioner heat pumps,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with louvered sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20 000 Btu/h</td>
<td>–</td>
<td></td>
<td>9.0 EER</td>
</tr>
<tr>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td></td>
<td>8.5 EER</td>
</tr>
<tr>
<td><strong>Room air conditioner heat pumps,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without louvered sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;14 000 Btu/h</td>
<td>–</td>
<td></td>
<td>8.5 EER</td>
</tr>
<tr>
<td>≥14 000 Btu/h</td>
<td>–</td>
<td></td>
<td>8.0 EER</td>
</tr>
</tbody>
</table>
For SI units: 1000 British thermal units per hour = 0.293 kW, °C = (°F-32)/1.8

Notes:
1 Section 12 of 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 shall be factory labeled as follows: “MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION 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). Where 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 greater than 15 000 Btu/h (4.4 kW), use 15 000 Btu/h (4.4 kW) in the calculation.

<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 conditioner, casement only</td>
<td>All capacities</td>
<td>–</td>
<td>8.7 EER</td>
<td>ANSI/ 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></td>
</tr>
</tbody>
</table>

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

Notes:
1 Section 12 of ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
2 EC = combustion efficiency. Units shall 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.
3 Minimum and maximum ratings as provided for and allowed by the unit’s controls.
4 Combination units not covered by NAEC (three-phase power or cooling capacity greater than or equal to 65 000 Btu/h (19 kW) shall be permitted to comply with either rating.
5 Multiple firing rate units shall be at the maximum firing rate.

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY1</th>
<th>TEST PROCEDURE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm air furnace, gas-fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity42</td>
<td>78% AFUE or 80% Et24</td>
<td>DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, of CSA Z21.47</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td>Maximum capacity42</td>
<td>80% Et24</td>
<td>Section 2.39, Thermal Efficiency, of CSA Z21.47</td>
</tr>
<tr>
<td>Warm air furnace, oil-fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity42</td>
<td>78% AFUE or 80% Et24</td>
<td>DOE 10 CFR Part 430 or Section 42, Combustion, of UL 727</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td>Maximum capacity42</td>
<td>81% Et24</td>
<td>Section 42, Combustion, UL 727</td>
</tr>
<tr>
<td>Warm air duct furnaces, gas-fired</td>
<td>All capacities</td>
<td>Maximum capacity42</td>
<td>80% Ec24</td>
<td>Section 2.10, Efficiency, of CSA Z83.8</td>
</tr>
<tr>
<td>Warm air unit heaters, gas-fired</td>
<td>All capacities</td>
<td>Maximum capacity42</td>
<td>80% Ec24</td>
<td>Section 2.10, Efficiency, of CSA Z83.8</td>
</tr>
<tr>
<td>Warm air unit heaters, oil-fired</td>
<td>All capacities</td>
<td>Maximum capacity42</td>
<td>80% Ec24</td>
<td>Section 40, Combustion, of UL 731</td>
</tr>
</tbody>
</table>

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

Notes:
1 Et = thermal efficiency. See test procedure for detailed discussion.
2 EC = combustion efficiency. Units shall 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.
3 Minimum and maximum ratings as provided for and allowed by the unit’s controls.
4 Combination units not covered by NAEC (three-phase power or cooling capacity greater than or equal to 65 000 Btu/h (19 kW) shall be permitted to comply with either rating.
5 Maximum and minimum ratings as provided for and allowed by the unit’s controls.
6 EC = combustion efficiency (100 percent less flue losses). See test procedure for detailed discussion.
7 As of August 8, 2008, according to the Energy Policy Act of 2005, units shall also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue dampar. A vent damper is an acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the conditioned space.
TABLE 503.7.1(6)
GAS AND OIL-FIRED BOILERS, MINIMUM EFFICIENCY REQUIREMENTS

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>MINIMUM EFFICIENCY 2, 3</th>
<th>EFFICIENCY AS OF 3/2/2010 2</th>
<th>EFFICIENCY AS OF 3/2/2020 3</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers, hot water</td>
<td>Gas-fired</td>
<td>&lt;300 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h 4</td>
<td>75% Ec</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/h 1</td>
<td>80% Ec</td>
<td>82% Ec</td>
<td>82% Ec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil-fired 5</td>
<td>&lt;300 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h 4</td>
<td>78% Et</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/h 1</td>
<td>83% Ec</td>
<td>84% Ec</td>
<td>84% Ec</td>
<td></td>
</tr>
<tr>
<td>Boilers, steam</td>
<td>Gas-fired</td>
<td>&lt;300 000 Btu/h</td>
<td>75% AFUE</td>
<td>75% AFUE</td>
<td>75% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired – except natural draft</td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h 4</td>
<td>75% Et</td>
<td>79% Ec</td>
<td>79% Ec</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h 1</td>
<td>80% Ec</td>
<td>79% Ec</td>
<td>79% Ec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas-fired – natural draft</td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h 4</td>
<td>75% Et</td>
<td>77% Et</td>
<td>79% Et</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h 1</td>
<td>80% Ec</td>
<td>77% Ec</td>
<td>79% Ec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil-fired 5</td>
<td>&lt;300 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h 4</td>
<td>78% Et</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/h 1</td>
<td>83% Ec</td>
<td>81% Ec</td>
<td>81% Ec</td>
<td></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 (2344 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.
3 Et = thermal efficiency. 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-tired (residual).
6 Date three years after ASHRAE Board Approval
7 Date thirteen years after ASHRAE Board Approval
### TABLE E 503.7.1(7)
**PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT**

[ASHRAE 90.1: TABLE 6.8.1G]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>PERFORMANCE REQUIRED&lt;sup&gt;1, 2, 3&lt;/sup&gt;</th>
<th>TEST PROCEDURE&lt;sup&gt;4, 5&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller or axial fan open-circuit cooling towers</td>
<td>All 95°F entering water</td>
<td>≥ 38.2 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td>85°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan open-circuit cooling towers</td>
<td>All 95°F entering water</td>
<td>≥ 20.0 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td>85°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan closed-circuit cooling towers</td>
<td>All 102°F entering water</td>
<td>≥14.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td>90°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan closed-circuit cooling towers</td>
<td>All 102°F entering water</td>
<td>≥7.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td>90°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air-cooled condensers</td>
<td>All 125°F condensing temperature R-22 test fluid</td>
<td>≥176 000 Btu/h·hp</td>
<td>AHRI 460</td>
</tr>
<tr>
<td></td>
<td>190°F entering gas temperature 15°F subcooling 95°F entering db</td>
<td>&gt;176 000 Btu/h·hp</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

**Notes:**
1. For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating at the thermal rating condition listed in Table E 503.7.1(7) divided by the fan motor nameplate rating.
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. Section 12 of 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.

### TABLE E 503.7.1(8)
**HEAT TRANSFER EQUIPMENT**

[ASHRAE 90.1: TABLE 6.8.1h]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY</th>
<th>MINIMUM EFFICIENCY&lt;sup&gt;1&lt;/sup&gt;</th>
<th>TEST PROCEDURE&lt;sup&gt;2&lt;/sup&gt;</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. Section 12 of ASHRAE 90.1 contains complete specification of the referenced test procedure, including the referenced year version of the test procedure.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUB-CATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRF Air Conditioners</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System</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>Electric Resistance (or none)</td>
<td>VRF Multi-Split System</td>
<td>11.2 EER 12.2 IEER 13.1 IEER (as of 7/1/2012)</td>
<td>AHRI 1230</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 Multi-Split System</td>
<td>11.0 EER 12.3 IEER 12.9 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric Resistance (or none)</td>
<td>VRF Multi-Split System</td>
<td>10.0 EER 11.1 IEER 11.6 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW.
### TABLE E 503.7.1(10)
MINIMUM EFFICIENCY REQUIREMENTS FOR ELECTRICALLY OPERATED VARIABLE REFRIGERANT FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS
[ASHRAE 90.1: TABLE 6.8.1J]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUB-CATEGORY 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 Multi-Split System</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>Electric Resistance (or none)</td>
<td>VRF Multi-Split System</td>
<td>11.0 EER 12.3 IEER 12.9 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric Resistance (or none)</td>
<td>VRF Multi-Split System with Heat Recovery</td>
<td>10.8 EER 12.1 IEER 12.7 IEER (as of 7/1/2012)</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 Multi-Split System with Heat Recovery</td>
<td>10.4 EER 11.6 IEER 12.1 IEER (as of 7/1/2012)</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric Resistance (or none)</td>
<td>VRF Multi-Split System with Heat Recovery</td>
<td>9.3 EER 10.4 IEER 10.8 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
<tr>
<td>VRF Water Source (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split Systems 86°F entering water</td>
<td>12.0 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split Systems with Heat Recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split Systems 86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split Systems with Heat Recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split Systems 86°F entering water</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split Systems with Heat Recovery 86°F entering water</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td>VRF Groundwater Source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System 59°F entering water</td>
<td>16.2 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System with Heat Recovery 59°F entering water</td>
<td>16.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System 59°F entering water</td>
<td>13.8 EER</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT TYPE</td>
<td>SIZE CATEGORY</td>
<td>HEATING SECTION TYPE</td>
<td>SUB-CATEGORY OR RATING CONDITION</td>
<td>MINIMUM EFFICIENCY</td>
<td>TEST PROCEDURE</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>---------------</td>
<td>----------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>VRF Groundwater Source (cooling mode)</td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System with Heat Recovery 59°F entering water</td>
<td>13.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System 77°F entering water</td>
<td>13.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System with Heat Recovery 77°F entering water</td>
<td>13.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System 77°F entering water</td>
<td>11.0 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-Split System with Heat Recovery 77°F entering water</td>
<td>10.8 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></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-Split System 47°F db/43°F wb outdoor air</td>
<td>3.3 COP</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-Split System 47°F db/43°F wb outdoor air</td>
<td>17°F db/15°F wb outdoor air</td>
<td>2.25 COP</td>
</tr>
<tr>
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<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</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>17°F db/15°F wb outdoor air</td>
<td>2.05 COP</td>
</tr>
<tr>
<td>VRF Water Source (heating mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-Split System 68°F entering water</td>
<td>4.2 COP</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>—</td>
<td>VRF Multi-Split System 68°F entering water</td>
<td>3.9 COP</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</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</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</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</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW
### TABLE E 503.7.1(11)

**AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS**

**[ASHRAE 90.1: TABLE 6.8.1K]**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY</th>
<th>MINIMUM SCOP-127(^2) EFFICIENCY DOWN-FLOW UNITS/UPFLOW UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Conditioners, air cooled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>2.20 / 2.09</td>
<td></td>
<td>ASHRAE 127</td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>1.90 / 1.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Conditioners, water cooled</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>2.60 / 2.49</td>
<td></td>
<td>ASHRAE 127</td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>2.40 / 2.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Conditioners, water cooled with fluid economizer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>2.55 / 2.44</td>
<td></td>
<td>ASHRAE 127</td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>2.35 / 2.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td></td>
<td></td>
<td>ASHRAE 127</td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.15 / 2.04</td>
<td></td>
<td></td>
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<tr>
<td>≥240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Conditioners, glycol cooled (rated at 40% propylene glycol) with fluid economizer</td>
<td></td>
<td></td>
<td>ASHRAE 127</td>
</tr>
<tr>
<td>&lt;65 000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥240 000 Btu/h</td>
<td>2.05 / 1.94</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

**Notes:**

1. Net sensible cooling capacity: the total gross cooling capacity minus the latent cooling, minus the energy to the air movement system (total gross - latent - fan power)

2. Sensible coefficient of performance (SCOP-127): a ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding re-heaters and humidifiers) at conditions in accordance with ASHRAE 127. The net sensible cooling capacity is the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

### TABLE E 503.7.4(01)

**MINIMUM DUCT INSULATION R-VALUE\(^1\), COOLING AND HEATING ONLY SUPPLY DUCTS AND RETURN DUCTS**

**[ASHRAE 90.1: TABLE 6.8.2A]**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>EXTERIOR</th>
<th>VENTILATED ATTIC</th>
<th>UNVENTED ATTIC ABOVE INSULATED CEILING</th>
<th>UNVENTED ATTIC WITH ROOF INSULATION (^1)</th>
<th>UNCONDITIONED SPACE (^2)</th>
<th>INDIRECTLY CONDITIONED SPACE (^3)</th>
<th>BURIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEATING ONLY DUCTS</td>
<td></td>
<td></td>
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<td></td>
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<td>5</td>
<td>R-6</td>
<td>R-3.5</td>
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<td>none</td>
<td>none</td>
<td>none</td>
<td>R-3.5</td>
</tr>
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<td>R-3.5</td>
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<td>none</td>
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<td>R-3.5</td>
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<td>R-3.5</td>
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<td>R-6</td>
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<td>R-6</td>
<td>R-6</td>
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<tr>
<td>COOLING ONLY DUCTS</td>
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<td></td>
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<td>R-3.5</td>
<td>R-3.5</td>
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<tr>
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<td>R-3.5</td>
<td>R-3.5</td>
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<tr>
<td>RETURN DUCTS</td>
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</tr>
<tr>
<td>1 to 8</td>
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<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>
Notes:

1 Insulation R-values, measured in [Btu•in/(h•ft²•°F)] [W/(m•K)], 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 are used as plenum walls, wall insulation shall be in accordance with the most restrictive condition of Section E 503.4.2 or Section 5 of ASHRAE 90.1. 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 crawlspaces, both ventilated and nonventilated.

3 Includes return air plenum, with or without exposed roofs above.

### TABLE E 503.7.12(142)
MINIMUM DUCT INSULATION R-VALUE¹ FOR COMBINED HEATING AND COOLING SUPPLY DUCTS AND RETURN DUCTS
[ASHRAE 90.1: TABLE 6.8.2B]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DUCT LOCATION</th>
<th>EXTERIOR</th>
<th>VENTILATED ATTIC</th>
<th>UNVENTED ATTIC ABOVE INSULATED CEILING</th>
<th>UNVENTED ATTIC WITH ROOF INSULATION¹</th>
<th>UNCONDITIONED SPACE²</th>
<th>INDIRECTLY CONDITIONED SPACE³</th>
<th>BURIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPPLY DUCTS</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
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<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
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<td>R-6</td>
<td>R-8</td>
<td>R-3.5</td>
<td>R-3.5</td>
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<td>none</td>
<td>R-3.5</td>
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<td>R-6</td>
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<td>R-6</td>
<td>R-8</td>
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<td>R-8</td>
<td>R-3.5</td>
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<td>R-8</td>
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<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>R-3.5</td>
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<tr>
<td>RETURN DUCTS</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1 to 8</td>
<td>R-3.5</td>
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<td>none</td>
</tr>
</tbody>
</table>

Notes:

1 Insulation R-values, measured in [Btu•in/(h•ft²•°F)] [W/(m•K)], 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 are used as plenum walls, wall insulation shall be in accordance with the most restrictive condition of Section E 503.4.2 or Section 5 of ASHRAE 90.1. 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 crawlspaces, both ventilated and nonventilated.

3 Includes return air plenum, with or without exposed roofs above.
TABLE E 503.7.1
MINIMUM PIPE INSULATION THICKNESS HEATING AND HOT WATER SYSTEMS
(STEAM, STEAM CONDENSATE, HOT WATER HEATING AND DOMESTIC WATER SYSTEMS) 1,2,3,4,5
ASHRAE 90.1-07: TABLE 6.8.3A

<table>
<thead>
<tr>
<th>FLUID DESIGN OPERATING TEMPERATURE RANGE (°F)</th>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONDUCTIVITY Btu/ft²•hr•°F</td>
<td>MEAN RATING TEMPERATURE, °F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;1</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>

COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT) 2,3

<table>
<thead>
<tr>
<th>FLUID DESIGN OPERATING TEMPERATURE RANGE (°F)</th>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;40</td>
</tr>
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<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></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:
   \[ T = r \left(1 + \frac{t}{r}\right) - 1 \]
   Where:
   \[ T = \text{minimum insulation thickness (inches)} \]
   \[ r = \text{actual outside radius of pipe (inches)} \]
   \[ t = \text{insulation thickness listed in this table for applicable fluid temperature and pipe size} \]
   \[ K = \text{conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature [Btu•in/(h•ft²•°F)] [W/(m•K)]} \]
   \[ k = \text{the upper value of the conductivity range listed in this table for the applicable fluid temperature} \]
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. For piping 1 1/2 inches (40 mm) or less, and located in partitions within conditioned spaces, reduction of installation thickness by 1 inch (25.4 mm) shall be permitted before the thickness adjustment required in footnote 1, but not a thickness less than 1 inch (25.4 mm).
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. For direct-buried heating and hot water system piping, reduction of insulation thickness by 1 1/2 inches (38 mm) shall be permitted before the thickness adjustment required in footnote 1, but not a thickness less than 1 inch (25.4 mm).
5 Table E 503.7.2(3) is based on steel pipe. Non-metallic pipes less than schedule 80 thickness shall use the table values. For other non-metallic pipes having thermal resistance greater 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 heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.2(3).
TABLE E 503.7.2(4)
MINIMUM PIPE INSULATION THICKNESS FOR COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)

[ASHRAE 90.1: TABLE 6.8.3B]

<table>
<thead>
<tr>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLUID OPERATING TEMPERATURE RANGE (°F) AND USAGE</td>
<td>CONDUCTIVITY Btu-inch/(h•F•°F)</td>
</tr>
<tr>
<td>40°F - 60°F</td>
<td>0.21 - 0.27</td>
</tr>
<tr>
<td>&lt;40°F</td>
<td>0.20 - 0.26</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)]

1 For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

\[ T = \frac{r(1 + \nu r^{\frac{1}{K}})}{} \]

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·F·°F)]/[W/(m·k)].
- \( \delta \) = 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 is not required for direct-buried cooling system piping.

4 Table E 503.7.2(4) is based on steel pipe. Non-metallic pipes less than schedule 80 thickness shall use the table values. For other non-metallic pipes having thermal resistance greater 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 heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.2(4).

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:
Ventilation during construction shall be achieved through openings in the building shell using fans to produce not less than three air changes per hour.

During dust-producing operations, the supply and return HVAC system openings shall be protected from dust in accordance with Section E 603.1.3.

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.

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, based on ASHRAE 52.2, or an average efficiency of 30 percent based on ASHRAE 52.1. 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 (4267.2 m³/m²) of occupiable building area. An internal temperature of not less 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 605.1.3.3, 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 Whole-Building Ventilation. A mechanical exhaust system, supply system, or combination thereof shall be installed for each dwelling unit to provide whole-building ventilation with outdoor air each hour at not less than the rate specified in Table E 605.1.3 or, equivalently, Equation E 605.1.3(1) and Equation E 605.1.3(2), based on the floor area of the conditioned space and number of bedrooms. [ASHRAE 62.2:4.1]

\[
Q_{fan} = 0.01A_{floor} + 7.5 \times (N_{br} + 1)
\]

Where:
- \(Q_{fan}\) = fan flow rate, cubic feet per minute (ft³/min)
- \(A_{floor}\) = floor area, square foot (ft²)
- \(N_{br}\) = number of bedrooms; not to be less than one

\[
Q_{fan} = 0.05A_{floor} + 3.5(N_{br} + 1)
\]

Where:
- \(Q_{fan}\) = fan flow rate, ft³/min
- \(A_{floor}\) = floor area, 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

**Exception:** Whole-building mechanical systems shall not be required provided one or more of the following conditions exists:

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, and the Authority Having Jurisdiction determines that window operation is a locally permissible method of providing ventilation.

E 605.1.3.1 Different Occupant Density. Table E 605.1.3, Equation E 605.1.3(1), and Equation E 605.1.3(2) 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 62.2:4.1.1]

E 605.1.3.2 Alternative Ventilation. Other methods shall be permitted to be used to provide the required ventilation rates (in accordance with Table E 605.1.3) where approved by a licensed design professional. [ASHRAE 62.2:4.1.2]

E 605.1.3.3 Infiltration Credit. Section E 605.1.3 includes a default credit for ventilation provided by infiltration of 2 ft³/min per 100 square feet [0.0001 (m³/s)/m²] of occupiable floor space. For buildings built prior to the application of this appendix, where excess infiltration has been measured using ASHRAE 136, the rates in Section E 605.1.3 shall be permitted to be decreased by half of the excess of the rate calculated from ASHRAE 136 that is above the default rate. [ASHRAE 62.2:4.1.3]

E 605.1.4 System Type. The whole-house 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. 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 Appendix B of 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 ventilation system as installed and shall be measured using a flow hood, flow grid, or other airflow measuring device. 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. The “fan on” switch on a heating or air-conditioning system shall be permitted as an operational control for systems introducing ventilation air through a duct to the return side of an HVAC system. Readily accessible override control shall be provided to the occupant. Local exhaust fan switches and “fan-on” switches shall be permitted as override controls. Controls, including the “fan-on” switch of a conditioning system, shall be appropriately labeled.

**Exception:** An intermittently operating, whole-house mechanical ventilation system shall be permitted to be used where the ventilation rate is adjusted according to the exception to Section E 605.1.6. The system shall be designed so that it operates automatically based on a timer. The intermittent mechanical ventilation system shall operate not less than once per day and must operate not less than 10 percent of the time. [ASHRAE 62.2:4.4]
TABLE E 605.1.3*
VENTILATION AIR REQUIREMENTS, (cubic foot per minute)
[ASHRAE 62.2: TABLE 4.1a]

<table>
<thead>
<tr>
<th>FLOOR AREA (ft²)</th>
<th>0-1</th>
<th>2-3</th>
<th>4-5</th>
<th>6-7</th>
<th>&gt;7</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1500</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>1501-3000</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
</tr>
<tr>
<td>3001-4500</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
<td>120</td>
</tr>
<tr>
<td>4501-6000</td>
<td>75</td>
<td>90</td>
<td>105</td>
<td>120</td>
<td>135</td>
</tr>
<tr>
<td>6001-7500</td>
<td>90</td>
<td>105</td>
<td>120</td>
<td>135</td>
<td>150</td>
</tr>
<tr>
<td>&gt;7500</td>
<td>105</td>
<td>120</td>
<td>135</td>
<td>150</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
* Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.

E 605.1.67 Delivered Ventilation. The delivered ventilation rate shall be calculated as the larger of the total supply or total exhaust and shall be not less than specified in Section E 605.1.3 during each hour of operation.

Exception: The effective ventilation rate of an intermittent system is the combination of its delivered capacity, fractional on-time, cycle time, and the ventilation effectiveness from Table E 605.1.6. The fan flow rate required to achieve an effective ventilation rate that is equivalent to the continuous ventilation requirement shall be calculated from the following equation [ASHRAE 62.2:4.5]:

\[ Q_f = \frac{Q_r}{(E \cdot f)} \]  
(Equation E 605.1.67)

Where:
- \( Q_f \) = fan flow rate during the on-cycle
- \( Q_r \) = ventilation air requirement (from Table E 605.1.3)
- \( T_{cyc} \) = fan cycle time, defined as the total time for 1 on-cycle and 1 off-cycle (used in Table E 605.1.67)
- \( E \) = ventilation effectiveness (from Table E 605.1.67)
- \( F \) = fractional on time, defined as the on-time for one cycle divided by the cycle time.

See ASHRAE 24 for an example of this calculation. For values not listed, use the next higher value for cycle time or the next lower value for fractional on-time shall be used. Linear interpolation shall be permitted for intermediate fractional on-times. The maximum allowed cycle time shall be 24 hours and the minimum allowed fractional on-time shall be 0.1.

TABLE E 605.1.67
VENTILATION EFFECTIVENESS FOR INTERMITTENT FANS²
[ASHRAE 62.2: TABLE 4.2]

<table>
<thead>
<tr>
<th>FRACTIONAL ON-TIME, f</th>
<th>0 to 6</th>
<th>8</th>
<th>12</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1.00</td>
<td>0.87</td>
<td>0.65</td>
<td>See footnote 1</td>
</tr>
<tr>
<td>0.2</td>
<td>1.00</td>
<td>0.90</td>
<td>0.76</td>
<td>See footnote 1</td>
</tr>
<tr>
<td>0.3</td>
<td>1.00</td>
<td>0.93</td>
<td>0.83</td>
<td>See footnote 1</td>
</tr>
<tr>
<td>0.4</td>
<td>1.00</td>
<td>0.95</td>
<td>0.88</td>
<td>0.46</td>
</tr>
<tr>
<td>0.5</td>
<td>1.00</td>
<td>0.96</td>
<td>0.92</td>
<td>0.68</td>
</tr>
<tr>
<td>0.6</td>
<td>1.00</td>
<td>0.98</td>
<td>0.95</td>
<td>0.81</td>
</tr>
<tr>
<td>0.7</td>
<td>1.00</td>
<td>0.99</td>
<td>0.97</td>
<td>0.90</td>
</tr>
<tr>
<td>0.8</td>
<td>1.00</td>
<td>0.99</td>
<td>0.99</td>
<td>0.96</td>
</tr>
<tr>
<td>0.9</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99</td>
</tr>
<tr>
<td>1.0</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Notes:
1 Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.
2 Interpolation in Table E 605.1.6 is not allowed. For values not listed, use the next higher value for Cycle Time or the next lower value for Fractional On-Time. The maximum allowed cycle time is 24 hours and the minimum allowed fractional on-time is 0.1.

E 605.1.78 Restrictions on System Type. Use of certain ventilation strategies is restricted in specific climates as follows. [ASHRAE 62.2:4.6]

**E 605.1.78.1 Hot, Humid Climates.** In hot, humid climates, whole-house mechanical net exhaust flow shall not exceed 7.5 ft³/min per 100 square feet [0.0004 (m³/s)/m²]. (See Section 5 of ASHRAE 62.2 for a listing of hot, humid US climates) [ASHRAE 62.2:4.6.1]

**E 605.1.78.2 Very Cold Climates.** Mechanical supply systems exceeding 7.5 ft³/min per 100 square feet [0.0004 (m³/s)/m²] shall not be used in very cold climates. (See Section 8 of ASHRAE 62.2 for a listing of very cold US climates)

**Exception:** These ventilation strategies are not restricted where the Authority Having Jurisdiction approves the envelope design as being moisture resistant. [ASHRAE 62.2:4.6.2]

**E 605.2 Bathroom Exhaust Fans.** Except where a whole house energy recovery ventilation 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 Section 4 through Section 7 of 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, Section 6.1.

**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. The 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, 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.
5. Functional performance.
7. Post construction documentation and training.
8. Commissioning report.

HVAC systems and components covered by this appendix as well as process equipment and controls, and renewable energy systems shall be included in the scope of the commissioning requirements.

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 specifica-
tions. 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.
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.

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**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 technician shall sign the certificate of acceptance to certify that the information he provides on the certificate of acceptance is true and correct.

**E 803.2.1.2 Responsible Person.** The responsible person shall be the contractor, architect, or engineer. A certificate of acceptance shall be signed by a responsible person to take responsibility for the scope of work specified by the certificate of acceptance document. The responsible person shall perform the field testing and verification work, and where this is the case, the responsible person shall complete and sign both the field technician’s signature block and the responsible person’s signature block on the certificate of acceptance form. The responsible person assumes responsibility for the acceptance testing work performed by the field technician agent or employee.

**E 803.2.1.3 Certificate of Acceptance.** The certificate of acceptance shall be submitted to the Authority Having Jurisdiction in order to receive the final certificate of occupancy. The Authority Having Jurisdiction shall not release a final certificate of occupancy unless the submitted certificate of acceptance demonstrates that the specified systems and equipment have been shown to be performing in accordance with the applicable acceptance requirements. The Authority Having Jurisdiction has the authority to require the field technician and responsible person to demonstrate competence, to its satisfaction. Certificate of acceptance forms are located in Section E 806.0.
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).
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, engineer 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, engineer 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 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 air 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 or 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. The 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 comply 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 airflows or 30 percent of the total design airflow. Verify and document the following:

1. Measured outside 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 outside 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 air volume 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 outside 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:

1. Thermostat is located within the space-conditioning zone that is served by the HVAC system.
2. Thermostat shall be in accordance with temperature adjustment and dead band requirements.
3. Occupied, unoccupied, and holiday schedules shall be programmed per the facility’s schedule.
4. Preoccupancy purge is programmed.

E 805.3.1.2 Functional Testing. The functional testing shall comply 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 where 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 locations:
(1) Outdoors.
(2) A space directly under a roof where the U-factor of the roof is greater than the U-factor of the ceiling.
(3) A space directly under a roof with fixed vents or openings to the outside or unconditioned spaces.
(4) An unconditioned crawlspace.
(5) 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 be in accordance 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 503.4.4.2.

**E 805.4.2 Acceptance Criteria.** Flexible ducts are not compressed or constricted. Duct connections shall be in accordance 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 503.4.4.2.

**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.

For units with economizers that are factory installed and certified operational by the manufacturer to economizer quality control requirements, the in-field economizer functional tests do not have to be conducted. A copy of the manufacturer’s certificate shall be attached to the Form MECH-5A. However, the construction inspection, including compliance with high temperature lockout temperature setpoint, shall be completed regardless of whether the economizer is field or factory installed.

**E 805.5.1 Test Procedure.** The procedure for performing a functional test for air economizer controls shall be in accordance 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 comply 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 shall 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 comply 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 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.
The outdoor air damper shall modulate open where the carbon dioxide concentration within the space exceeds setpoint.

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 variable air valve (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 comply 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 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 comply 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 comply 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 be in accordance with the following steps:

**Step 1:** Open control valves to increase water flow to not less than 90 percent design flow. 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.
3. System operation shall stabilize within 5 minutes after test procedures are initiated.

**Step 2:** Modulate control valves to reduce water flow to 50 percent of the design flow or less, but not lower than the pump minimum flow. Verify and document the following:

1. Pump speed decrease.
2. Current operating setpoint has decreased (for systems with DDC to the zone level).
3. Current operating setpoint has not increased (for all other systems).
4. System pressure is within 5 percent of current operating setpoint.
5. System operation stabilizes within 5 minutes after test procedures are initiated.

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 be in accordance 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.
2. 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 deadband to not more than 2°F (-1.1°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 lockout 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 805.12.1.2 Functional Testing. The functional testing shall comply be in accordance with the following steps:

Step 1: Test low airflow condition by replacing the existing filter with a dirty filter or appropriate obstruction.

Step 2: Verify that the fault detection and diagnostics system reports the fault.

Step 3: Verify that the system is able to verify the correct refrigerant charge.

Step 4: Calibrate outside air, return air, and supply air temperature sensors.

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 compliance 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 comply be in accordance with Section E 805.13.1.1(A) and Section E 805.13.1.1(B).

E 805.13.1.1(A) 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:
From the control system workstation, command the mixing box dampers to full open (100 percent outdoor air).

Disconnect power to the actuator and verify that a fault is reported at the control workstation.

Reconnect power to the actuator and command the mixing box dampers to full open.

Verify that the control system does not report a fault.

From the control system workstation, command the mixing box dampers to a full-closed position (0 percent outdoor air).

Disconnect power to the actuator and verify that a fault is reported at the control workstation.

Reconnect power to the actuator and command the dampers closed.

Verify that the control system does not report a fault during normal operation.

Step 3: Valve/actuator fault: 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:

From the control system workstation, override the heating coil valve and verify that a fault is reported at the control workstation.

From the control system workstation, override the cooling coil valve and verify that a fault is reported at the control workstation.

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(B) 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:

Disconnect the tubing to the differential pressure sensor of the VAV box.

Verify that control system detects and reports the fault.

Reconnect the sensor and verify proper sensor operation.

Verify that the control system does not report a fault.

Step 2: Damper/actuator fault:

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.

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):

Command the reheat coil valve to full open.

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.

Reconnect the actuator and restore normal operation.

Step 4: Feedback loop tuning fault (unstable airflow):

Set the integral coefficient of the box controller to a value 50 times the current value.

The damper cycles continuously and airflow is unstable. Verify that the control system detects and reports the fault.

Reset the integral coefficient of the controller to the original value to restore normal operation.

Step 5: Disconnected inlet duct:

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 comply 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.

Step 4: Simulate a cooling load during morning shoulder time period. Verify and document the following:

(1) 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
E 805.15.1 Test Procedure. The procedure for performing a functional test for thermal energy storage (TES) system shall comply 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 comply 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 indoor air temperature setpoint below the ambient temperature. Verify that the tank starts discharging and the compressor is off.

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.

### TABLE 1701.0

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
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<tr>
<td>AHRI 1230-2010*</td>
<td>Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment</td>
<td>Refrigerants</td>
<td>Table E 503.7.1(9), Table E 503.7.1(10)</td>
</tr>
<tr>
<td>ASHRAE 24-2008</td>
<td>Ventilation and Indoor Air Quality in Low-Rise Residential Buildings</td>
<td>Ventilation</td>
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<tr>
<td>ASHRAE 127-2012*</td>
<td>Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners</td>
<td>Air Conditioners</td>
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<tr>
<td>ISO 13256-2-1998</td>
<td>Water-Source Heat Pumps – Testing and Rating for Performance</td>
<td>Water-Source Heat Pumps</td>
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<td>SMACNA 016-2012*</td>
<td>HVAC Air Duct Leakage Test Manual</td>
<td>Ducts</td>
<td>E 502.4.3.1, E 503.4.7.2(A), E 503.4.7.2(B)</td>
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<tr>
<td>SMACNA Guideline-1995</td>
<td>IAQ Guidelines for Occupied Buildings Under Construction</td>
<td>Ventilation</td>
<td>E 603.1.1</td>
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<tr>
<td>TIA 942-A-2012*</td>
<td>Telecommunications Infrastructure Standard for Data Centers</td>
<td>Air Conditioners</td>
<td>E 503.5</td>
</tr>
</tbody>
</table>

**Note:** ASHRAE 127, ASHRAE 154, and ISO 13256-2 meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.
Note: AHRI 1230, ASHRAE 24, SMACNA 016, SMACNA Guideline, and TIA 942-A do not meet the requirements for mandatory reference standards in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

(portions of table not shown remain unchanged)

SUBSTANTIATION:
This proposal updates Appendix E of the UMC to the HVAC portions of the 2012 IAPMO Green Plumbing and Mechanical Code Supplement.

COMMITTEE ACTION: Accept as Submitted

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Tim Ross, Ross Distributing Inc.

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

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 British thermal units per hour (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 502.4.1 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 [2.86 2.87 E-11 kg/(Pa•s•m2)] where tested in accordance with Procedure A in ASTM E96.

Insulation is not required where the ducts are within the conditioned space. [ASHRAE 90.2:6.4]

<table>
<thead>
<tr>
<th>TABLE E 502.9</th>
<th>MINIMUM REQUIREMENTS FOR NON-FEDERALLY COVERED HVAC EQUIPMENT</th>
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<tr>
<td><strong>EQUIPMENT TYPE</strong></td>
<td><strong>SUBCATEGORY OR RATING CONDITION</strong></td>
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<tr>
<td>Groundwater source heat pump*</td>
<td>Cooling Mode</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Heating Mode</td>
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<tr>
<td>Unitary A/C</td>
<td>Water cooled split system</td>
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<td></td>
<td>Evaporatively cooled split system</td>
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<td></td>
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</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 Standard 325.

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 deadband, the range of which includes a setting of 10°F (±5°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 502.10.4 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 shutting 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 shutting 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 shutoff 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 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 this section E 503.0. [ASHRAE 90.1:6.1.1.1]

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 90.1:6.1.1.2]

E 503.1.2 Additions to Existing Buildings. Mechanical equipment and systems serving the heating, cooling, or 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. Exception: Where HVACR to an addition is provided by existing HVACR systems and equipment, such existing systems and equipment shall not be required to be in accordance with the energy consumption categories in this standard. However, any new systems or equipment installed shall be in accordance with specific requirements applicable to those systems and equipment. [ASHRAE 90.1:6.1.1.3.1]

E 503.1.3 Alterations to Heating, Ventilating, and Air-Conditioning, and Refrigeration in Existing Buildings. New HVACR equipment as a direct replacement of existing HVACR equipment shall be in accordance with the specific minimum efficiency requirements applicable to that equipment. [ASHRAE 90.1:6.1.1.3.2]

E 503.1.3.2 Existing Cooling Systems. Alterations to existing cooling systems shall not decrease economizer capability unless the system is in accordance with Section E 503.5 through Section 503.5.4.1. [ASHRAE 90.1:6.1.1.3.3]

E 503.1.3.3 Ductwork. New and replacement ductwork shall comply with Section E 503.4.7.1 and through Section E 503.4.7.2(A). [ASHRAE 90.1:6.1.1.3.4]

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 for the following or both 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 pipes piping where there is insufficient space or access to meet 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 through Section E 503.3.4. 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 503.5.8. [ASHRAE 90.1:6.2.1]

E 503.2.1 Projects Using Energy Cost Budget Method. Exception: Projects using the energy cost budget method in accordance with ASHRAE 90.1, provided such projects are in accordance 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 is 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. Each 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. [ASHRAE 90.1:6.3.2(a)]

2. The equipment shall comply with the variable flow requirements of Section 503.4.6.1 503.5.6.2. [ASHRAE 90.1:6.3.2(b)]

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 503.7.1(1) (air conditioners), Table 503.7.1(2) (heat pumps), or Table 503.7.1(4) (packaged terminal and room air conditioners and heat pumps) for the applicable equipment category. [ASHRAE 90.1:6.3.2(c)]

4. The system shall have an air economizer in accordance with Section 503.5 through Section 503.5.4.1. [ASHRAE 90.1:6.3.2 (d)]

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 503.7.1(2) (heat pumps) or Table 503.7.1(4) (packaged terminal and room air conditioners and heat pumps), a fuel-fired furnace that meets is in accordance with the applicable efficiency requirements shown in Table 503.7.1(5) (furnaces, duct furnaces, and unit heaters), an electric resistance heater, or a baseboard system connected to a boiler that meets is in accordance with the applicable efficiency requirements shown in Table 503.7.1(6) (boilers). [ASHRAE 90.1:6.3.2(e)]

6. The system shall comply with the exhaust air energy requirements in accordance with Section 503.5.10. [ASHRAE 90.1:6.3.2(f)]

7. The system shall be controlled by a manual changeover or dual setpoint thermostat. [ASHRAE 90.1:6.3.2(g)]

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 is 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 where outside outdoor air temperature is less than 40°F (4°C).

   Exceptions: Heat Pumps that comply with the following:
   1) Have Heat pumps where minimum efficiency is regulated by NAECAt and whose HSPF rating are both
   2) in accordance with the requirements shown in Table 503.7.1(2), and
   3) Includes usage of internal electric resistance heating are exempted from the control requirements of this part [Section 503.3.1(9)]. [ASHRAE 90.1:6.3.2(h)]

9. The system controls shall not permit reheat or other form of simultaneous heating and cooling for humidity control. [ASHRAE 90.1:6.3.2(i)]

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 greater more than 15 000 Btu/h (4.4 kW) and a supply fan motor power greater 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. 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. Capable of temperature setback down to 55°F (13°C) during off hours.
   e. Capable of temperature setup to 90°F (32°C) during off hours. [ASHRAE 90.1:6.3.2(j)]

11. Except for piping within manufacturer’s units, HVAC piping shall be insulated in accordance with Table 503.7.2(1) and Table 503.7.2(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. [ASHRAE 90.1:6.3.2(k)]

12. Ductwork and plenums shall be insulated in accordance with Table 503.7.2(1) and Table 503.7.2(2) and shall be sealed in accordance with Table 503.4.7.2 Section 503.4.7.2. [ASHRAE 90.1:6.3.2(l)]

13. Construction documents shall require a ducted system to be air balanced in accordance with industry-accepted procedures. [ASHRAE 90.1:6.3.2(m)]
Outdoor air intake and exhaust systems shall comply with Section E 503.4.6.4 through Section E 503.4.6.5. [ASHRAE 90.1:6.3.2(m)]

Where separate heating and cooling equipment serves the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling. [ASHRAE 90.1:6.3.2(o)]

Systems with a design supply air capacity more than 10 000 ft³/min (4.7195 m³/s) shall have optimum start controls. [ASHRAE 90.1:6.3.2(p)]

The system shall comply with the demand control ventilation requirements of Section E 503.4.6.503.4.6.9. [ASHRAE 90.1:6.3.2(q)]

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(11) 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 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
(2) Table E 503.7.1(2) – Electrically Operated Unitary and Applied Heat Pumps
(3) Table E 503.7.1(3) – Water-Chilling (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
(5) Table E 503.7.1(5) – Warm-Air Furnaces, Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters
(6) Table E 503.7.1(6) – Gas- and Oil-Fired Boilers
(7) Table E 503.7.1(7) – Performance Requirements for Heat Rejection Equipment
(8) Table E 503.7.1(8) – Heat Transfer Equipment
(9) Table E 503.7.1(9) – Electrically Operated Variable-Refrigerant-Flow Air Conditioners
(10) Table E 503.7.1(10) – Electrically Operated Variable-Refrigerant-Flow Air-to-Air and Applied Heat Pump
(11) Table E 503.7.1(11) – Air Conditioners and Condensing Units Serving Computer Rooms

Furnaces with input ratings of not less than 225 000 Btu/h (66 kW), 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 under the scope of ASHRAE 127 shall be in accordance with Table E 503.7.1(11). Other air conditioners shall comply with 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°F (7°C) leaving chilled fluid temperature and 2.4 gallons per minute per ton (gpm/ton) (0.00015 L/s/kg) evaporator fluid flow and 85°F (29°C) entering condenser-fluid temperature with 3.0 gallons per minute per ton (gpm/ton) (0.000218 L/s/kg) condenser-fluid flow shall have maximum full-load kW/ton (FL) and NPLV part-load ratings requirements adjusted using the following equation in accordance with Equation E 503.4.1(1) through Equation E 503.4.1(3):

\[
\text{Adjusted maximum full-load kW/ton rating} = \frac{\text{full-load kW/ton from Table E 503.7.1(3)}}{K_{adj}}
\]

\[
\text{Adjusted maximum NPLV rating} = \frac{\text{IPLV from Table E 503.7.1(3)}}{K_{adj}}
\]

\[K_{adj} = A \times B\]

\[F_{L,adj} = F/L_{K,adj}\]

\[P_{L,adj} = I/IPLV_{K,adj}\]

\[K_{adj} = A \times B\]
Where:

\[ FL = \text{full-load kW/ton value from Table E 503.7.1(3)} \]

\[ FL_{adj} = \text{maximum full-load kW/ton rating, adjusted for nonstandard conditions} \]

\[ IPLV = \text{IPLV value from Table E 503.7.1(3)} \]

\[ IPLV_{adj} = \text{maximum NPLV rating, adjusted for nonstandard conditions} \]

\[ A = 0.00000014592 \times (LIFT)^4 + 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302 \]

\[ B = 0.0015 \times LvgEvap + 0.934 \]

\[ LIFT = LvgCond - LvgEvap \]

\[ LvgCond = \text{Full-load condenser leaving fluid temperature (°F)} \]

\[ LvgEvap = \text{Full-load evaporator leaving temperature (°F)} \]

The adjusted full-load \( FL_{adj} \) and \( NPLV_{adj} \) values shall only be applicable for centrifugal chillers in accordance with the following full-load design ranges:

1. Minimum Evaporator Leaving Temperature: 36°F (2°C)
2. Maximum Condenser Leaving Temperature: 115°F (46°C)
3. \( LIFT \) is not less than 20°F (-6°C) and not more than 80°F (27°C)

Manufacturers shall calculate the adjusted maximum kW/ton \( FL_{adj} \) and \( NPLV_{adj} \) before determining whether to label the chiller in accordance with Section E 503.4.4. Chillers shall be labeled in accordance with this appendix. 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 are not covered under this appendix.

Example: Path A, 600 ton (600 000 kg) centrifugal chiller Table E 503.7.1(3) efficiencies.

\[ FL = 0.570 \] kW/ton

\[ IPLV = 0.539 \] kW/ton

\[ LvgCond = 91.16°F \]

\[ LvgEvap = 42°F \]

\[ LIFT = 91.16°F - 42°F = 49.16°F \]

\[ K_{adj} = A \times B \]

\[ A = 0.00000014592 \times (49.16)^4 + 0.0000346496 \times (49.16)^3 + 0.00314196 \times (49.16)^2 - 0.147199 \times (49.16) + 3.9302 = 1.0228 \]

\[ B = 0.0015 \times 42 + 0.934 = 0.9970 \]

\[ FL_{adj} = 0.570 \times 0.9970 = 0.569 \] kW/ton

\[ NPLV_{adj} = 0.539 \times 0.9970 = 0.537 \] kW/ton

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
(5) Where components such as indoor or outdoor coils from different manufacturers are used, the system designer shall specify component efficiencies whose combined efficiency meets is in accordance with the minimum equipment efficiency requirements in Section E 503.4 through Section E 503.4.4.503.4.4.1.

(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 503.4.4.1 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 as follows in accordance with the following:

[“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 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.

(2) The perimeter system heating and cooling supply is controlled by a thermostatic control(s) located within the zones(s) served by the system.

Exterior walls are considered to have different orientations where the directions 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 a temperature range or dead band of not less than 5°F (−1.7°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 503.4.6.3(A) 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(B) Setback Controls. Heating systems located in climate zone 2 through zone 8 shall be equipped with controls that have the capability configured to automatically restart and temporarily operate the system as required to maintain zone temperatures above an adjustable heating setpoint adjustable down to 55°F (13°C) or lower of not less than 10°F (6°C) below the occupied heating setpoint. Cooling systems located in climate zones 1b, 2b, and 3b shall be equipped with controls that have the capability configured to automatically restart and temporarily operate the mechanical cooling system as required to maintain zone temperatures below an adjustable cooling setpoint adjustable up to 90°F (32°C) or higher of not less than 5°F (3°C) above the occupied cooling setpoint or to prevent high space humidity levels.

Exception: Radiant floor and ceiling heating systems 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(C) Optimum Start Controls. Individual heating and cooling air distribution systems with setback controls and DDC with a total design supply air capacity exceeding 10,000 ft³/min (4.7195 m³/s), served by one or more supply fans, shall have optimum start controls. The control algorithm shall, as a minimum, be a function of the difference between space temper-
nature and occupied setpoint, the outdoor air 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(D) 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 automatically shutting 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(A), Automatic Shutdown. For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for a length of time while serving 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 where other zones are inoperative. [ASHRAE 90.1:6.4.3.3.4]

**E 503.4.6.4(A) Shutoff Damper Controls.** Outdoor air supply intake and exhaust systems shall be equipped with motorized dampers that will automatically shut where the systems or spaces served are not in use. Ventilation outdoor air, and exhaust or relief dampers shall be capable of automatically shutting off during preoccupancy building warm-up, cooldown, and setback, except where ventilation reduces energy costs or where ventilation shall be supplied to be in accordance with the requirements of this code.

**Exceptions:**

1. Backdraft gravity (nonmotorized) dampers shall be permitted for exhaust and relief in buildings less than three stories above grade in height, and for ventilation air intakes and exhaust and relief dampers in buildings of any height located in climate zones 1 through zone 3. Backdraft 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]

**E 503.4.6.4(B) 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(B) where tested in accordance with AMCA 500 as indicated in Table E 503.4.6.4(D). [ASHRAE 90.1:6.4.3.4.3]

**E 503.4.6.4(C) Ventilation Fan Controls.** Fans with motors greater than 0.75 hp (0.56 kW) shall have automatic controls in accordance with Section E 503.4.6.3(A) that are capable of shutting off fans where 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.** Heated 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. [ASHRAE 90.1:6.4.3.4.5]

**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 ratio that exceeds 1500 square feet per horsepower (ft²/hp) (186.8 m²/kW) and do not utilize mechanical cooling or 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 HSPF 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]
Humidification and Dehumidification. Humidity control shall prevent the use of fossil fuel or electricity to produce relative humidity (RH) more than 30 percent in the warmest zone served by the humidification system and to reduce the RH valve to less than 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 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 configured to maintain a deadband of not less than 10 percent RH 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 to comply with applicable codes or accreditation standards or as approved by the Authority Having Jurisdiction. \[ASHRAE 90.1:6.4.3.7 6.4.3.6\]

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 shutting off the systems where outdoor air temperatures are above more than 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 shutting off the systems where the pavement temperature is above more than 50°F (10°C) and no precipitation is falling, and an automatic or manual control that will allow shutoff where the outdoor temperature is above more than 40°F (4°C) so that the potential for snow or ice accumulation is negligible. \[ASHRAE 90.1:6.4.3.8 6.4.3.7\]

Ventilation Controls for High-Occupancy Areas. Demand control ventilation (DCV) is required for spaces more than 500 square feet (46.45 m²) and with a design occupancy for ventilation of not less than 25 40 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 1200 ft³/min (0.5663 0.3540 m³/s).
4. Spaces where more than 75 percent of the supply space design outdoor airflow is required for makeup air that is exhausted from the space or rate minus a makeup or outgoing transfer air that is required for makeup air that is exhausted from other space(s) requirement is less than 1200 ft³/min (0.5663 m³/s).
5. Spaces with one of the following occupancy categories in accordance with Chapter 4 or in ASHRAE 62.1: correctional cells; daycare sickrooms; science labs; barbers; beauty and nail salons; and bowling alley seating. \[ASHRAE 90.1:6.4.3.9 6.4.3.8\]

Single Zone Variable-Air-Volume Controls. HVAC systems shall have variable airflow controls in accordance with the following:
1. Air handling and fan coil units with chilled water cooling coils and supply fans with motors greater than or equal to 5.26 hp (3.99 kW) shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands not more than 50 percent, the supply fan controls shall be able to reduce the airflow to not more than the larger of the following:
   a. One-half of the full fan speed.
   b. The volume of outdoor air required to comply with the ventilation requirements of ASHRAE 62.1.
2. Effective January 1, 2012, air conditioning equipment and air handling units with direct expansion cooling and a cooling capacity at AHRMA conditions not less than 110 000 Btu/h (32 kW) that serve single zones shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands not more than 50 percent, the supply fan controls shall be able to reduce the airflow to not more than the larger of the following:
   a. Two-thirds of the full fan speed.
   b. The volume of outdoor air required to be in accordance with the ventilation requirements of ASHRAE 62.1. \[ASHRAE 90.1:6.4.3.10\]
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.

Insulation. Insulation required by this section shall be installed in accordance with industry-accepted standards (see ASHRAE 90.1). 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]

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(1) and Table E 503.7.2(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 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 not exceeding 5 square feet (0.5 m²) need not be insulated. [ASHRAE 90.1:6.4.4.1.2]

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, or 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 mm) or less, insulation shall not be required for strainers, control valves, and balancing valves. [ASHRAE 90.1:6.4.4.1.3]

Sensible Heating Panel Insulation. Thermally ineffective panel surfaces of sensible heating panels, including U-bends and headers, shall be insulated with not less than R-3.5. Adjacent building envelope insulation shall be permitted to be applied to this insulation value. [ASHRAE 90.1:6.4.4.1.4]

D Radiant Floor Heating. The bottom surfaces of floor structures incorporating radiant heating shall be insulated not less than R-3.5. Adjacent building envelope insulation is permitted to be applied to this insulated value.

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]

Ducts and Plenum Leakage. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A in accordance with Table E 503.4.7.2(1), Table E 503.4.7.2(2) provides definitions of seal levels, as required to be in accordance with Section E 503.4.7.2(A), and with standard industry practice and SMACNA HVAC Duct Construction Standard, or ASHRAE 90.1. Openings for rotating shafts shall be sealed with bushings or devices that seal off air leakage. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified in accordance with UL 181A or UL 181B by an independent testing laboratory and the tape is used in accordance with that certification. All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that is capable of voiding the product listings shall not be required. Spiral lock seams shall be permitted to not be sealed. Duct pressure class ratings shall be designated in the design documents. [ASHRAE 90.1:6.4.4.2.1]
**TABLE E 503.4.7.2(1)**
MINIMUM DUCT SEAL LEVEL
[ASHRAE 90.1-07: TABLE 6.4.4.2A]

<table>
<thead>
<tr>
<th>DUCT LOCATION</th>
<th>SUPPLY ≤2 in.-w.c.²</th>
<th>SUPPLY &gt;2 in.-w.c.²</th>
<th>EXHAUST</th>
<th>RETURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>A</td>
<td>A</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Unconditioned spaces</td>
<td>B</td>
<td>B</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Conditioned spaces</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
</tbody>
</table>

For SI unit: 1 inch water column = 0.249 kPa

Notes:
1. See Table E 503.4.7.2(2) description of seal level.
2. Duct design static pressure classification.
3. Includes indirectly conditioned spaces such as return air plenums.

**TABLE E 503.4.7.2(2)**
DUCT SEAL LEVELS
[ASHRAE 90.1-07: TABLE 6.4.4.2B]

<table>
<thead>
<tr>
<th>SEAL LEVEL</th>
<th>SEALING REQUIREMENTS³⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>All transverse joints, longitudinal seams, and duct wall penetrations. 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. (See note)</td>
</tr>
<tr>
<td>B</td>
<td>All transverse joints, longitudinal seams. 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. (See note)</td>
</tr>
<tr>
<td>C</td>
<td>Transverse joints only.</td>
</tr>
</tbody>
</table>

Notes:
1. UL 181A or UL 181B is not applicable to metal-to-metal duct joints.
2. Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw, faucet, pipe, rod, or wire. Spiral lock seams in a round or flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, tape, and other branch connections, access door frames and jambs, duct connections to equipment, etc.

**E 503.4.7.2(A) Duct Leakage Tests.** Ductwork that is designed to operate at static pressures in excess of exceeding 3 inches water column (0.7 kPa) and ductwork located outdoors shall be leak-tested in accordance with SMACNA 016 industry-accepted test procedures. Representative sections totaling not less than 25 percent of the total installed duct area for the designated pressure class shall be tested. Duct systems with pressure ratings exceeding 3 inches water column (0.7 kPa) shall be identified on the drawings. Sections to be tested shall be selected by the building owner or designated representative of the building owner. Positive pressure leakage testing shall be acceptable for negative pressure ductwork. The permitted duct leakage shall be not more than the following calculations [ASHRAE 90.1:6.4.4.2.2]:

\[
L_{\text{max}} = CLP^{0.65}
\]  

[Equation E 503.4.7.2(A)]

Where:

\[
L_{\text{max}} = \text{maximum permitted leakage, in (ft}^3/\text{min)/100 square feet duct surface area.}
\]

\[
CL = \text{Six, duct leakage class, (ft}^3/\text{min)/100 square feet duct surface area at 1 inch water column. Six for rectangular sheet metal, rectangular fibrous, and round flexible ducts. Three for round/flat oval sheet metal or fibrous glass ducts.}
\]

\[
P = \text{test pressure, which shall be equal to the design duct pressure class rating in inch water column [based on ASHRAE 90.1:6.4.4.2.2]}
\]

For SI units: 1 cubic foot per minute = 0.00047m³/s, 1 square foot = 0.0929m², 1 inch water column = 0.249 kPa

**E 503.4.7.2(B) Duct Leakage Tests with Less than 3 inches Water Column.** Ductwork that is designed to operate at static pressures less than 2 inches water column (0.7 kPa) located outdoors and within unconditioned space shall be leak-tested in accordance with SMACNA 016. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

**E 503.5 Prescriptive Path.** Each cooling systems that has a fan shall include either an air or water economizer meeting the requirements of 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. Systems that include nonparticulate air treatment in accordance with ASHRAE 62.1.

3. Systems 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 with applicable codes or standards. In 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.

4. Systems that include a condenser heat recovery system with a minimum capacity in accordance with the IAPMO Green Plumbing & Mechanical Code Supplement Section E 503.5.10.1(B).

5. Systems that serve residential spaces where the system capacity is less than five times the requirement listed in Table E 503.5(1).

6. 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).

7. Systems expected to operate less than 20 hours per week.

8. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

9. For comfort cooling where the cooling efficiency is not less than the efficiency improvement requirements in accordance with Table E 503.3.1 503.5(3).

10. Systems primarily serving computer rooms where in accordance with the following:
   a. The total design cooling load of 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 not more 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 allow cooling towers.
   d. Less than 600 000 Btu/h (176 kW) of computer room cooling equipment capacity is being added to an existing building.

11. Dedicated systems for computer rooms where a minimum of 75 percent of the design load serves 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 E 503.5(1)
**MINIMUM FAN-COOLING UNIT SIZE FOR WHICH AN ECONOMIZER IS REQUIRED FOR COMFORT COOLING**

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY FOR WHICH AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a, 1b</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2a, 2b, 3a, 4a, 5a, 6a, 3b, 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)
**MINIMUM FAN-COOLING UNIT SIZE FOR WHICH AN ECONOMIZER IS REQUIRED FOR COMPUTER ROOMS**

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>COOLING CAPACITY FOR WHICH AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a, 1b, 2a, 3a, 4a</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2b, 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
TABLE E 503.3.1
ELIMINATE REQUIRED ECONOMIZER FOR COMFORT COOLING BY INCREASING COOLING EFFICIENCY
[ASHRAE 90.1: TABLE 6.3.2 6.5.1-3]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</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 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.

E 503.5.1.2 High-Limit Shutoff. Air economizers shall be capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity where outdoor air intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table E 503.5.1.2(1). High-limit shutoff control settings for these control types shall be those listed in Table E 503.5.1.2(2) 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]

**TABLE E 503.5.1.2(1)***
HIGH-LIMIT SHUTOFF CONTROL OPTIONS
FOR AIR ECONOMIZERS
[ASHRAE 90.1: TABLE 6.5.1.1.3A]

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>ALLOWED CONTROL TYPES</th>
<th>PROHIBITED CONTROL TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b, 2b, 3b, 3c, 4b, 4a, 5b, 5c, 6b, 7, 8</td>
<td>Fixed dry bulb, Differential dry bulb, Electronic enthalpy*</td>
<td>Fixed enthalpy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Differential enthalpy, Dew-point and dry-bulb temperatures</td>
</tr>
<tr>
<td>1a, 2a, 3a, 4a</td>
<td>Fixed enthalpy, Electronic enthalpy*</td>
<td>Fixed dry bulb, Differential dry bulb</td>
</tr>
<tr>
<td></td>
<td>Dew-point and dry-bulb temperatures</td>
<td></td>
</tr>
<tr>
<td>5a, 6a</td>
<td>Fixed dry bulb, Differential dry bulb, Electronic enthalpy*</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Differential enthalpy, Dew-point and dry-bulb temperatures</td>
<td></td>
</tr>
</tbody>
</table>

*Electronic enthalpy controllers are devices that use a combination of humidity and dry-bulb temperature in their switching algorithm.
### TABLE E 503.5.1.2(2)
HIGH-LIMIT SHUTOFF CONTROL SETTINGS FOR AIR ECONOMIZERS

[ASHRAE 90.1: TABLE 6.5.1.1.3B]

<table>
<thead>
<tr>
<th>CONTROL DEVICE-TYPE</th>
<th>ALLOWED ONLY IN CLIMATE ZONE AT LISTED SETPOINT</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN WHERE):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EQUATION</td>
</tr>
<tr>
<td>Fixed dry bulb temperature</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8, 5a, 6a</td>
<td>$T_{oa} &gt; 75^\circ \text{F}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{oa} &gt; 70^\circ \text{F}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{oa} &gt; 65^\circ \text{F}$</td>
</tr>
<tr>
<td>Differential dry bulb temperature</td>
<td>2b, 3b, 3c, 4b, 5a, 5b, 6a, 7, 8</td>
<td>$T_{oa} &gt; T_{ra}$</td>
</tr>
<tr>
<td>Fixed enthalpy with fixed dry-bulb temperature</td>
<td>2a, 3a, 4a, 5a, 6a</td>
<td>$h_{oa} &gt; 28 \text{ Btu/lb}^1$ or $T_{oa} &gt; 75^\circ \text{F}$</td>
</tr>
<tr>
<td>Electronic enthalpy</td>
<td>All</td>
<td>$(T_{oa} - RH_{oa}) &gt; A$</td>
</tr>
<tr>
<td>Differential enthalpy with fixed dry-bulb temperature</td>
<td>All</td>
<td>$h_{oa} &gt; h_{ra}$ or $T_{oa} &gt; 75^\circ \text{F}$</td>
</tr>
<tr>
<td>Dew-point and dry bulb temperatures</td>
<td>All</td>
<td>$DP_{oa} &gt; 55^\circ \text{F}$ or $T_{oa} &gt; 75^\circ \text{F}$</td>
</tr>
</tbody>
</table>

For SI units: °C = °(F-32)/1.8, 1 British thermal unit per pound = 2326 J/kg, 1 grain = 0.0000648 kg

**Notes:**

1. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F (24°C) and 50 percent relative humidity. As an example, at approximately 6000 feet (1829 m) elevation, the fixed enthalpy limit is shall be approximately 30.7 Btu/lb (71408 J/kg).

2. Setpoint “A” corresponds to a curve on the psychrometric chart that goes through a point at approximately 75°F (24°C) and 40 percent relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels. 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.

---

**E 503.5.3 Dampers.** Return air, exhaust or relief, and outdoor air dampers shall comply with Section E 503.4.6.4(B) through Section E 503.4.6.12. [ASHRAE 90.1:6.5.1.1.4]

**E 503.5.2 Water Economizers.** Water economizer systems shall be capable of cooling supply air by indirect evaporation and 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 where in which 100 percent of the expected system cooling load at the 40°F (4°C) dry bulb and or the 35°F (2°C) wet bulb in accordance with Table E 503.5.2 is achieved using with evaporative water economizers.

2. Systems primarily serving computer rooms with dry cooler water economizers that provide in which 100 percent of the expected system cooling load at the 45°F (7°C) dry bulb temperatures in accordance with Table E 503.5.2 is achieved with dry cooler water 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 using with evaporative water economizers. [ASHRAE 90.1:6.5.1.2.1]
TABLE E 503.5.2
WATER ECONOMIZER SIZING DRY-BULB AND WET-BULB REQUIREMENTS FOR COMPUTER ROOMS
[ASHRAE 90.1: TABLE 6.5.1.2.1]

<table>
<thead>
<tr>
<th>ZONE</th>
<th>EVAPORATIVE WATER ECONOMIZER</th>
<th>DRY COOLER WATER ECONOMIZER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRY BULB, °F</td>
<td>WET BULB, °F</td>
</tr>
<tr>
<td>1</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>35.0</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>30.0</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>30.0</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
<td>35.0</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>7</td>
<td>=</td>
<td>30.0</td>
</tr>
<tr>
<td>8</td>
<td>=</td>
<td>30.0</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F - 32) / 1.8

E 503.5.2.1 Maximum Pressure Drop. Precooling coils and water-to-water heat exchangers used as part of a water 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 providing partial cooling even where additional mechanical cooling is required to meet 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]

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 6.5.1.5]

E 503.5.5.4 503.5.4.1 Economizer Humidification System Impact. Systems with hydronic cooling and humidification systems designed to maintain inside humidity at a dew-point temperature greater than 35°F (2°C) shall use a water economizer where an economizer is required by in accordance with Section E 503.5 through Section 503.5.4.1. [ASHRAE 90.1:6.5.2.4 6.5.1.6]

E 503.5.5 Simultaneous Heating and Cooling Limitation. Zone thermostatic controls shall be provided to 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) Thirty percent of the zone design peak supply rate.
(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) **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.

(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.
(d) 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 with Section E 503.5.11.2.

(4) Zones where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (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 floor shall not supply heating air more than 20°F (−7°C) above the space temperature setpoint.

**Exceptions:**

(1) Laboratory exhaust systems in accordance with Section E 503.5.11.2.

(2) During reoccupancy building warm-up and setback. [ASHRAE 90.1:6.5.2.1.1]

**E 503.5.5.2(B) Two-Pipe Changeover System.** Systems that use a common distribution system to supply both heated and chilled water are acceptable provided where in accordance with the following requirements are met:

(1) The system is designed to allow a dead band between changeover from one mode to the other of not less than 15°F (−9°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(C) 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 providing a heat pump water supply temperature dead band of not less than 20°F (−7°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 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 tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass heat pump water flow around the tower. Where an open-circuit 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 (−7.1°C) shall be permitted. [ASHRAE 90.1:6.5.2.2.3]

E 503.5.5.3 Dehumidification. Where humidistatic 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 configured to reduce capable of reducing 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 80 000 Btu/h (19 23.4 kW) and is capable of unloading 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) or less. 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 the building includes site-recovered or site solar energy source that provide energy 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 75 90 percent of the annual energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (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 90.1-07:6.5.2.4.1]

E 503.4.6.7 503.5.5.4 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 90.1:6.4.3.6 6.5.2.4.1]

E 503.5.6 Air System Design and Control. HVAC 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 and through Section E 503.5.6.4 503.5.6.5. [ASHRAE 90.1:6.5.3]

E 503.5.6.1 Fan System Power Limitation and Efficiency. Each HVAC systems 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. Single-zone variable-air-volume systems shall comply with the constant-volume fan power limitation. [ASHRAE 90.1:6.5.3.1.1]

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(1)
FAN POWER LIMITATION*
[ASHRAE 90.1: TABLE 6.5.3.1.1A 5.5.3.1-1]

<table>
<thead>
<tr>
<th>OPTION</th>
<th>LIMIT</th>
<th>CONSTANT VOLUME</th>
<th>VARIABLE VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Fan System</td>
<td>Allowable Nameplate Motor (hp)</td>
<td>hp ≤ CFMS × 0.0011</td>
<td>hp ≤ CFMS × 0.0015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option 2: Fan System (bhp)</td>
<td>Allowable Fan System (bhp)</td>
<td>bhp ≤ CFMS × 0.00094 + A</td>
<td>bhp ≤ CFMS × 0.0013 + A</td>
</tr>
</tbody>
</table>

For SI units: 1 horsepower = 0.746 kW, 1 cubic foot per minute = 0.00047 m³/s

*Where:

- \( CFMS \) = 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)
- \( A \) = sum of \((PD \times CFM_D)\)

\( PD \) = 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)

TABLE E 503.5.6.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT
[ASHRAE 90.1: TABLE 6.5.3.1.1B 5.5.3.1-2]

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully ducted return, exhaust, or both air systems</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>(2.2 x energy recovery effectiveness) ≥ 0.5 in w.c. for each airstream</td>
</tr>
<tr>
<td>Coil runaround loop</td>
<td>0.6 in. w.c. for each airstream</td>
</tr>
<tr>
<td>Evaporative humidifiers 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

For SI units: 1 inch water column = 0.249 kPa, 1 foot = 304.8 mm

**E 503.5.6.1(A) Motor Nameplate Horsepower.** For a fan, the selected fan motor shall be not larger than the first available motor size greater 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 with 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. [ASHRAE 90.1:6.5.3.1.2]

**E 503.5.6.2 VAV Fan Control (Including Systems Using Series Fan Power Boxes).** Individual VAV fans with motors 40 hp (27.5 kW) and larger shall meet one of the following:
The fan shall be driven by a mechanical or electrical variable-speed drive.

The fan shall be a vane axial fan with variable-pitch blades.

The fan shall have other controls and devices that will result in fan motor demand of not more than 30 percent of design wattage at 50 percent of design air volume where static pressure setpoint equals one-third of the total design static pressure, based on manufacturer's certified fan data. [ASHRAE 90.1:6.5.3.2.1]

**E 503.5.6.2 Fan Airflow Control.** Cooling systems listed in Table E 503.5.6.2 shall be designed to vary the indoor fan airflow as a function of load and shall be in accordance with the following:

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 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 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 Section E 503.5 through Section E 503.5.4.1 shall have not less than 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 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 90.1:6.5.3.2.1]

**TABLE E 503.5.6.2
EFFECTIVE DATES FOR FAN 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</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>≥2/3</td>
<td>Any</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 503.5.6.2(A) VAV Static Pressure Sensor Location.** Static pressure sensors used to control VAV fans shall be placed in a position located such that the controller setpoint is not greater than one-third 1.2 inches water column (0.30 kPa) the total design fan static pressure, except for systems with zone reset control in accordance with Section E 503.5.6.2(B). Where this results in the sensor being located downstream of major duct splits, multiple sensors shall be installed in each major branch to ensure that static pressure is maintained in each.

**Exceptions:**

Systems that are in accordance with section E 503.5.6.2(B). [ASHRAE 90.1:6.5.3.2.2]

**E 503.5.6.2(B) Setpoint Reset.** For systems with DDC of individual zone boxes reporting to the central control panel, static pressure setpoint shall be reset based on the zone requiring the most pressure (e.g., 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]

**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 con-
controls shall reset the supply air temperature to not less than 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 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 or site solar energy sources. [ASHRAE 90.1:6.5.3.4]

E 503.5.6.5 Fractional Horsepower Fan Motors. Motors for fans that are \( \frac{1}{12} \) 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: 6.5.3.5]

<table>
<thead>
<tr>
<th>TABLE E 503.5.6.5(1)</th>
<th>MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR POLYPHASE SMALL ELECTRIC MOTORS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER OF POLES</td>
<td>OPEN MOTORS</td>
</tr>
<tr>
<td>SYNCHRONOUS SPEED</td>
<td>3600</td>
</tr>
<tr>
<td>MOTOR HORSEPOWER</td>
<td>2</td>
</tr>
<tr>
<td>EFFICIENCY, %</td>
<td>65.6</td>
</tr>
<tr>
<td>0.25</td>
<td>69.5</td>
</tr>
<tr>
<td>0.33</td>
<td>73.4</td>
</tr>
<tr>
<td>0.50</td>
<td>76.8</td>
</tr>
<tr>
<td>0.75</td>
<td>82.5</td>
</tr>
<tr>
<td>1</td>
<td>86.5</td>
</tr>
<tr>
<td>1.5</td>
<td>86.9</td>
</tr>
<tr>
<td>2</td>
<td>85.5</td>
</tr>
<tr>
<td>3</td>
<td>86.5</td>
</tr>
</tbody>
</table>

*Average full-load efficiencies shall be established in accordance with 10 CFR 431.

<table>
<thead>
<tr>
<th>TABLE E 503.5.6.5(2)</th>
<th>MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND ( ) INDUCTION-RUN SMALL ELECTRIC MOTORS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER OF POLES</td>
<td>OPEN MOTORS</td>
</tr>
<tr>
<td>SYNCHRONOUS SPEED</td>
<td>3600</td>
</tr>
<tr>
<td>MOTOR HORSEPOWER</td>
<td>2</td>
</tr>
<tr>
<td>EFFICIENCY, %</td>
<td>66.6</td>
</tr>
<tr>
<td>0.25</td>
<td>70.5</td>
</tr>
<tr>
<td>0.33</td>
<td>72.4</td>
</tr>
<tr>
<td>0.50</td>
<td>76.2</td>
</tr>
<tr>
<td>0.75</td>
<td>80.4</td>
</tr>
<tr>
<td>1</td>
<td>81.5</td>
</tr>
<tr>
<td>1.5</td>
<td>84.5</td>
</tr>
<tr>
<td>2</td>
<td>84.1</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Average full-load efficiencies shall be established in accordance with 10 CFR 431.
E 503.5.7 Hydronic System Design and Control. HVAC hydronic systems having a total pump system power exceeding 10 hp (7.5 kW) shall be in accordance with Section E 503.5.7.1 through Section E 503.5.7.4. 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 90.1-07:6.5.4.1]

<table>
<thead>
<tr>
<th>BOILER SYSTEM DESIGN INPUT, Btu/h</th>
<th>MINIMUM TURNDOWN RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1,000,000 and &gt;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. HVAC pumping systems having a total pump system power exceeding 10 hp (7.5 kW) that include 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 reducing pump flow rates to 50 percent or less of the design flow rate. Individual chilled-water pumps serving variable-flow systems having motors exceeding 5 hp (3.7 kW) shall have controls, devices, or both (such as variable-speed control) 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 be in accordance with this section, and DDC controls are used, the setpoint shall be reset downward based on valve positions until one valve is nearly wide open.

Exceptions:

1. Systems where the minimum flow is less than the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system, such as chillers, and where total pump system power is 75 hp (55.9 kW) or less.

2. Systems that include not more than three control valves. [ASHRAE 90.1:6.5.4.42]

E 503.5.7.2 Pump 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 plant is capable of being automatically reduced or shut off, correspondingly, where the chiller is shut down. Chillers referred to in this section, 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(A) Boiler Isolation. Where a boiler plant includes more than one boiler, provisions shall be made so that the flow through the boiler plant is capable of being automatically reduced or shut off, correspondingly, 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 90.1:6.5.4.3.2]

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.

Exceptions:

1. Where the supply temperature reset controls are not capable of being implemented without causing improper operation of heating, cooling, humidifying, or dehumidifying systems.

2. Hydronic systems, such as those required in Section E 503.5.7 that use variable flow to reduce pumping energy. [ASHRAE 90.1:6.5.4.4.6.5.4.4]

E 503.5.7.4 Hydronic (Water Loop) Heat Pump and Water-Cooled Unitary Air Conditioner Systems. 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 90.1:6.5.4.46.5.4.5.1]
E 503.5.7.4(A) 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 pump motor demand of not more than 30 percent of design wattage at 50 percent of design water flow. [ASHRAE 90.1:6.5.4.4.2 6.5.4.5.2]

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 segment does not exceed the values listed in Table E 503.5.7.5 for the appropriate total annual hours of operation. Pipe size selections for systems that operate under variable flow conditions, such as 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. [ASHRAE 90.1:6.5.4.5]

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 is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during 30 percent or more of operating hours.
2) Piping systems that have not more than the total pressure drop of 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]

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE, (INCHES)</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1/2</td>
<td>120</td>
<td>180</td>
<td>85</td>
<td>130</td>
<td>68</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>270</td>
<td>140</td>
<td>210</td>
<td>110</td>
<td>170</td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>530</td>
<td>260</td>
<td>400</td>
<td>210</td>
<td>320</td>
</tr>
<tr>
<td>5</td>
<td>410</td>
<td>620</td>
<td>310</td>
<td>470</td>
<td>250</td>
<td>370</td>
</tr>
<tr>
<td>6</td>
<td>740</td>
<td>1100</td>
<td>570</td>
<td>860</td>
<td>440</td>
<td>680</td>
</tr>
<tr>
<td>8</td>
<td>1200</td>
<td>1800</td>
<td>900</td>
<td>1400</td>
<td>700</td>
<td>1100</td>
</tr>
<tr>
<td>10</td>
<td>1800</td>
<td>2700</td>
<td>1300</td>
<td>2000</td>
<td>1000</td>
<td>1600</td>
</tr>
<tr>
<td>12</td>
<td>2500</td>
<td>3800</td>
<td>1900</td>
<td>2900</td>
<td>1500</td>
<td>2300</td>
</tr>
</tbody>
</table>

Maximum velocity for pipes over 42-44-24 inches in size:
8.5 ft/s 13.0 ft/s 6.5 ft/s 9.5 ft/s 5.0 ft/s 7.5 ft/s

For SI units: 1 gallon per minute = 0.06 L/s, 1 foot per second = 0.3048 m/s, 1 inch = 25.4 mm

E 503.5.8 Heat Rejection Equipment. Section E 503.5.8 and 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. Each fan powered by a motor of 7.5 hp (5.59 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change 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.
2) Condenser fans serving flooded condensers.
3) Installations located in climate zone 1 and zone 2.
4) Up to one-third of the fans on a condenser or tower with multiple fans, where the lead fans are in accordance with the speed control requirement. [ASHRAE 90.1:6.5.5.2.1]

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 meet comply with the energy efficiency requirement for axial fan open-circuit cooling towers listed 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 503.5.10 Exhaust Air Energy Recovery. A fan system shall have an energy recovery system where the system’s supply 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 have 50 percent or more energy recovery effectiveness. Fifty percent energy recovery effectiveness shall be the change in the enthalpy of the outdoor air supply equal to 50 percent of the difference between the outdoor air and return 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 meeting 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. Systems exhausting toxic, flammable, paint, corrosive fumes, or dust.
4. Commercial kitchen hoods used for collecting and removing grease vapors and smoke.
5. Where more than 60 percent of the outdoor air heating energy is provided from site-recovered or site-solar energy.
6. Heating systems energy recovery in climate zones 1 and zone 2.
7. Cooling systems energy recovery in climate zones 3c, 4c, 5c, 6b, 7, and 8.
8. Where the largest exhaust source of air exhausted at a single location at the building exterior is less than 75 percent of the design outdoor airflow rate.
9. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
10. Systems expected to operate less than 20 hours or less 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)

<table>
<thead>
<tr>
<th>ZONE</th>
<th>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>3B, 3C, 4B, 4C, 5B</td>
<td>3B, 3C, 4B, 4C, 5B</td>
<td>≥10% and ≥20% and ≥30% and ≥40% and ≥50% and ≥60% and ≥70% and ≥80%</td>
<td>≥28 000 and ≥26 000 and ≥11 000 and ≥5500 and ≥4500 and ≥3500 and ≥2500 and ≥1500</td>
</tr>
<tr>
<td>1B, 2B, 5C</td>
<td>1B, 2B, 5C</td>
<td>≥10% and ≥20% and ≥30% and ≥40% and ≥50% and ≥60% and ≥70% and ≥80%</td>
<td>≥26 000 and ≥16 000 and ≥5500 and ≥4500 and ≥3500 and ≥2000 and ≥1000</td>
</tr>
<tr>
<td>6B</td>
<td>6B</td>
<td>≥10% and ≥20% and ≥30% and ≥40% and ≥50% and ≥60% and ≥70% and ≥80%</td>
<td>≥4500 and ≥4000 and ≥2500 and ≥1000</td>
</tr>
<tr>
<td>1A, 2A, 3A, 4A, 5A, 6A</td>
<td>1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥10% and ≥20% and ≥30% and ≥40% and ≥50% and ≥60% and ≥70% and ≥80%</td>
<td>≥4500 and ≥4000 and ≥2500 and ≥1000</td>
</tr>
<tr>
<td>7, 8</td>
<td>7, 8</td>
<td>≥10% and ≥20% and ≥30% and ≥40% and ≥50% and ≥60% and ≥70% and ≥80%</td>
<td>≥4500 and ≥4000 and ≥2500 and ≥1000</td>
</tr>
</tbody>
</table>

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*
[ASHRAE 90.1: TABLE 6.5.6.1-2]

For SI units: 1 cubic foot per minute = 0.00047 m$^3$/s
*N—Not required

E 503.5.10.1(B) 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.
(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 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, site-recovered energy, or from other sources. [ASHRAE 90.1:6.5.6.2.2]

E 503.5.11.1 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 90.1:6.5.7.1.1]

E 503.5.11.1(A) Conditioned Supply Air. Conditioned supply air delivered to a space with a kitchen hood 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 hood exhaust flow minus the available transfer air from adjacent spaces. Available transfer air is that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces. [ASHRAE 90.1:6.5.7.1.2]

E 503.5.11.2(A) Kitchen or Dining Facility. Where a kitchen or dining facility has a total kitchen hood exhaust airflow rate more than 5000 ft$^3$/min (2.3597 m$^3$/s), then one of the following shall be provided:
(1) Fifty percent or more of replacement air is transfer air that would otherwise be exhausted.
(2) Demand ventilation system(s) provide 75 percent or more of the exhaust air. Such systems shall be capable of providing 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 with a sensible heat recovery effectiveness of 40 percent or more on 50 percent or more of the total exhaust airflow. [ASHRAE 90.1:6.5.7.1.4]

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 reducing exhaust airflow rates, makeup airflow rates, or both shall incorporate a heat recovery system to precondition makeup air from laboratory exhaust and shall be in accordance with the following:
$$A + B \times \left(\frac{E}{M}\right) \geq 50\%$$  
(Equation E 503.5.11.3)
Where:
\[ A = \text{Percentage that the exhaust and makeup airflow rates are capable of being reduced from design conditions.} \]
\[ B = \text{Percentage sensible recovery effectiveness.} \]
\[ E = \text{Exhaust airflow rate through the heat recovery device at design conditions.} \]
\[ M = \text{Makeup airflow rate of the system at design conditions.} \]

(2) VAV laboratory exhaust and room supply systems required to have minimum circulation rates to be in accordance with the applicable codes or standards shall be capable of reducing zone exhaust and makeup airflow rates to the regulated minimum circulation values, or the minimum required to maintain pressurization relationship requirements. Nonregulated zones shall be capable of reducing 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 (\(\pm 1.1^\circ\text{C}\)) below room setpoint, cooled to not less than 3°F (\(\pm 1.7^\circ\text{C}\)) above room setpoint, no humidification is added, and no simultaneous heating and cooling are used for dehumidification control. [ASHRAE 90.1:6.5.7.2]

**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 enclosed space heating shall be in accordance with the governing provisions of 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. 
**Exception:** Unitary packaged systems with cooling capacities not greater than 90,000 Btu/h (26.4 kW). [ASHRAE 90.1:6.5.9]

<table>
<thead>
<tr>
<th>RATED CAPACITY</th>
<th>MAXIMUM HOT GAS BYPASS CAPACITY (percent of total capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤240,000 Btu/h</td>
<td>(45) 15%</td>
</tr>
<tr>
<td>&gt;240,000 Btu/h</td>
<td>(45) 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.
(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. [ASHRAE 90.1:6.7.1]

**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 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 include an operating and maintenance manual for that all lighting equipment and lighting controls, and a copy shall 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 503.6.5 Completion Requirements. The following requirements in Section E 503.6.5.1 through Section E 503.6.5.4(A) are mandatory provisions and are necessary to comply with this appendix. [ASHRAE 90.1:6.7.2]

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 (see ASHRAE 90.1) 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 setpoints. [ASHRAE 90.1:6.7.2.2]

E 503.7 Minimum Equipment Efficiency Tables. The minimum efficiency requirements for equipment shall comply with Section E 503.7.1, and duct insulation shall comply with Section E 503.7.2, and pipe insulation shall comply with Section E 503.7.3.

E 503.7.2 Duct Insulation Tables. Duct insulation shall comply with Table E 503.7.2(1) through Table E 503.7.2(4).

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 503.6 through Section E 503.6.5.4, and Section E 503.7. [ASHRAE 90.1:6.6.1]

E 503.8.1 Computer Room. The computer room PUE\textsubscript{1} shall be not more than the values listed in Table E 503.8.1. Hourly simulation of the proposed design, for purposes of calculating PUE\textsubscript{1}, shall be in accordance with ASHRAE 90.1.

Exceptions: 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 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>1A</td>
<td>1.61</td>
</tr>
<tr>
<td>2A</td>
<td>1.49</td>
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<tr>
<td>3A</td>
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<td>4A</td>
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<td>1.53</td>
</tr>
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<td>2B</td>
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</tr>
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<td>3B</td>
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<tr>
<td>4B</td>
<td>1.38</td>
</tr>
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<td>5B</td>
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<td>7</td>
<td>1.32</td>
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<td>8</td>
<td>1.30</td>
</tr>
</tbody>
</table>

*PUE₀ and PUE₁ shall not include energy for battery charging.

E 503.8.2 The computer room PUE₀ shall be not more than 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 electricity for an energy source. PUE₀ shall be calculated for the following 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 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]
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY1</th>
<th>TEST PROCEDURE2</th>
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<td>Split System</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
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<td>Split System</td>
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<td></td>
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<td>Split System</td>
<td>11.0 SEER</td>
<td></td>
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Air conditioner, evaporatively cooled

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<th>Type</th>
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<th>IEER (before 6/1/2011)</th>
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<td>10.8</td>
<td>12.2</td>
<td>10.9</td>
<td>11.7</td>
</tr>
</tbody>
</table>

AHRI 210/240

AHRI 340/360
For SI units: 1000 British thermal units per hour = 0.293 kW

Notes:
1. IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
2. ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.
3. Single-phase, air-cooled air conditioners less than 65 000 Btu/h (19 kW) are regulated by NAECA. SEER values shall be those set by NAECA.

<table>
<thead>
<tr>
<th>Condensing units, air cooled</th>
<th>≥135 000 Btu/h</th>
<th>Electric Resistance (or none)</th>
<th>Split system and single package</th>
<th>≥760 000 Btu/h</th>
<th>11.0 EER (before 6/1/2011)</th>
<th>11.7 EER (as of 6/1/2011)</th>
<th>11.1 IEER (before 6/1/2011)</th>
<th>11.9 IEER (as of 6/1/2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>Electric Resistance (or none)</td>
<td>Split system and single package</td>
<td>≥760 000 Btu/h</td>
<td>11.0 EER (before 6/1/2011)</td>
<td>11.7 EER (as of 6/1/2011)</td>
<td>11.1 IEER (before 6/1/2011)</td>
<td>11.9 IEER (as of 6/1/2014)</td>
</tr>
<tr>
<td>Condensing units, water cooled</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>–</td>
<td>≥760 000 Btu/h</td>
<td>11.0 EER (before 6/1/2011)</td>
<td>11.7 EER (as of 6/1/2011)</td>
<td>11.1 IEER (before 6/1/2011)</td>
<td>11.9 IEER (as of 6/1/2014)</td>
</tr>
<tr>
<td>Condensing units, evaporatively cooled</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>–</td>
<td>≥760 000 Btu/h</td>
<td>11.0 EER (before 6/1/2011)</td>
<td>11.7 EER (as of 6/1/2011)</td>
<td>11.1 IEER (before 6/1/2011)</td>
<td>11.9 IEER (as of 6/1/2014)</td>
</tr>
</tbody>
</table>

AHRI 365
## TABLE E 503.7.1(2)
ELECTRONICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS MINIMUM EFFICIENCY REQUIREMENTS
[ASHRAE 90.1-07: TABLE 6.8.1B-2]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY¹</th>
<th>TEST PROCEDURE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER (before 1/1/2015) 14 SEER (as of 1/1/2015)</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td>Through-the-wall (air cooled, cooling mode)</td>
<td>≤30 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Small duct high velocity, air cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>11.0 SEER</td>
<td></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>Split system and single package</td>
<td>11.0 EER 11.2 IEER (before 1/1/2016) 12.2 IEER (as of 1/1/2016)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER 11.0 IEER (before 1/1/2016) 12.0 IEER (as of 1/1/2016)</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>Split system and single package</td>
<td>10.6 EER 10.7 IEER (before 1/1/2016) 11.6 IEER (as of 1/1/2016)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.4 EER 10.5 IEER (before 1/1/2016) 11.4 IEER (as of 1/1/2016)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>9.5 EER 9.6 IEER (before 1/1/2016) 10.6 IEER (as of 1/1/2016)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>9.3 EER 9.4 IEER (before 1/1/2016) 10.4 IEER (as of 1/1/2016)</td>
<td></td>
</tr>
<tr>
<td>Water source to air, water loop (cooling mode)</td>
<td>&lt;17 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>14.2 EER 12.2 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td></td>
<td>≥17 000 Btu/h and &lt;65 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.0 EER 13.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>86°F entering water</td>
<td>12.0 EER 13.0 EER</td>
<td></td>
</tr>
<tr>
<td>Water source to air, groundwater source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>59°F entering water</td>
<td>16.2 EER 18.0 EER</td>
<td>ISO 13256-1</td>
</tr>
<tr>
<td>Brine to air, groundwater 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 source 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>Groundwater source to water, groundwater loop (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></td>
</tr>
</tbody>
</table>
For SI units: 1000 British thermal units per hour = 0.293 kW, °C = (°F-32)/1.8

Notes:
1. IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
2. ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.
3. Single-phase air-cooled heat pumps less than 65 000 Btu/h (19 kW) are regulated by NAECA; SEER and HSPF values shall be those set by NAECA.

<table>
<thead>
<tr>
<th>System Type</th>
<th>Cooling Capacity</th>
<th>Heating Capacity</th>
<th>EER/HSPF</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground source</td>
<td></td>
<td>Through-the-wall, air cooled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>system</td>
<td></td>
<td>(heating mode)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water to air, water loop source</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>77°F entering water</td>
<td>12.1 EER</td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td></td>
<td></td>
<td>Split system</td>
<td>7.7 HSPF (before 1/1/2015) 8.2 HSPF (as of 1/1/2015)</td>
</tr>
<tr>
<td>Through-the-wall, air cooled, (heating mode)</td>
<td></td>
<td></td>
<td>Split system</td>
<td>7.4 HSPF</td>
</tr>
<tr>
<td>Small duct high velocity, air cooled (heating mode)</td>
<td></td>
<td></td>
<td>Split system</td>
<td>6.8 HSPF</td>
</tr>
<tr>
<td>Through-the-wall, air cooled, (heating mode)</td>
<td></td>
<td></td>
<td>Single package</td>
<td>7.4 HSPF</td>
</tr>
<tr>
<td>Ground source</td>
<td></td>
<td>Through-the-wall, air cooled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>system</td>
<td></td>
<td>(heating mode)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water to air, water loop source</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>68°F entering water</td>
<td>4.2 4.3 COPH</td>
</tr>
<tr>
<td>Water to air, groundwater source</td>
<td>&lt;135 000 Btu/h</td>
<td></td>
<td>50°F entering water</td>
<td>3.6 3.7 COPH</td>
</tr>
<tr>
<td>Brine to air, groundwater source loop</td>
<td>&lt;135 000 Btu/h</td>
<td></td>
<td>32°F entering water</td>
<td>3.3 3.2 COPH</td>
</tr>
<tr>
<td>Water source water to water, water loop</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>68°F entering water</td>
<td>3.7 COPH</td>
</tr>
<tr>
<td>Groundwater source Water to water, R groundwater (heating mode)</td>
<td>&lt;135 000 Btu/h</td>
<td></td>
<td>50°F entering water</td>
<td>3.1 COPH</td>
</tr>
<tr>
<td>Ground source Brine to water, ground loop (heating mode)</td>
<td>&lt;135 000 Btu/h</td>
<td></td>
<td>32°F entering water</td>
<td>2.5 COPH</td>
</tr>
</tbody>
</table>
# TABLE E.603.7.1(3)

**WATER CHILLING PACKAGES — EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1C]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>BEFORE 1/1/2010</th>
<th>AS OF 1/1/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>PATH A3</td>
<td>PATH B3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>FULL LOAD</td>
<td>IRLV</td>
</tr>
<tr>
<td>Air-Cooled Chillers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;150 tons</td>
<td>EER</td>
<td>≥0.562</td>
<td>10.416</td>
<td>≥0.562</td>
</tr>
<tr>
<td>≥150 tons</td>
<td>EER</td>
<td>≥0.562</td>
<td>≥12.500</td>
<td>NA4</td>
</tr>
<tr>
<td>Air-cooled, without condenser, electrically operated</td>
<td>All-capacity</td>
<td>EER</td>
<td>≥10.586</td>
<td>≥11.782</td>
</tr>
<tr>
<td>Water-cooled, electrically operated, reciprocating</td>
<td>All-capacity</td>
<td>kW/ton</td>
<td>≤0.827</td>
<td>≤0.696</td>
</tr>
<tr>
<td>&lt;75 tons</td>
<td>kW/ton</td>
<td>≤0.790</td>
<td>≤0.676</td>
<td>≤0.780</td>
</tr>
<tr>
<td>≥75 tons and &lt;150 tons</td>
<td>kW/ton</td>
<td>≤0.790</td>
<td>≤0.676</td>
<td>≤0.775</td>
</tr>
<tr>
<td>≥150 tons and &lt;600 tons</td>
<td>kW/ton</td>
<td>≤0.717</td>
<td>≤0.627</td>
<td>≤0.680</td>
</tr>
<tr>
<td>≥600 tons and &lt;900 tons</td>
<td>kW/ton</td>
<td>≤0.630</td>
<td>≤0.571</td>
<td>≤0.620</td>
</tr>
<tr>
<td>Water-cooled, electrically operated, centrifugal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;150 tons</td>
<td>kW/ton</td>
<td>≤0.703</td>
<td>≤0.660</td>
<td>≤0.634</td>
</tr>
<tr>
<td>≥150 tons and &lt;400 tons</td>
<td>kW/ton</td>
<td>≤0.624</td>
<td>≤0.624</td>
<td>≤0.596</td>
</tr>
<tr>
<td>≥400 tons and &lt;600 tons</td>
<td>kW/ton</td>
<td>≤0.576</td>
<td>≤0.549</td>
<td>≤0.576</td>
</tr>
<tr>
<td>≥600 tons and &lt;900 tons</td>
<td>kW/ton</td>
<td>≤0.586</td>
<td>≤0.549</td>
<td>≤0.570</td>
</tr>
<tr>
<td>Air-cooled absorption single effect</td>
<td>All-capacity</td>
<td>COP</td>
<td>≥0.600</td>
<td>NR5</td>
</tr>
<tr>
<td>Water-cooled absorption single effect</td>
<td>All-capacity</td>
<td>COP</td>
<td>≥0.700</td>
<td>NR5</td>
</tr>
<tr>
<td>Absorption double effect, indirect-fired</td>
<td>All-capacity</td>
<td>COP</td>
<td>≥1.000</td>
<td>≥1.000</td>
</tr>
<tr>
<td>Absorption double effect, direct-fired</td>
<td>All-capacity</td>
<td>COP</td>
<td>≥1.000</td>
<td>≥1.000</td>
</tr>
</tbody>
</table>

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW

### Notes:

1. The centrifugal chiller equipment requirements after adjustment in accordance with Section E.503.4.1 shall not apply to chillers where the design leaving evaporator temperature is less than 36°F (2°C). The requirements shall not apply to positive displacement chillers with design leaving fluid temperatures 32°F (0°C) or less. The requirements shall not apply to absorption chillers with design leaving fluid temperatures less than 40°F (4°C).

2. ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

3. Compliance with this supplement can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or Path B.

4. NA means that this requirement is not applicable and cannot be used for compliance.

5. NR means that there are no minimum requirements for this category.
### TABLE E 503.7.1(3)
**WATER CHILLING PACKAGES - EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1-3][1]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>EFFECTIVE 1/1/2010 Path A</th>
<th>EFFECTIVE 1/1/2015 Path A</th>
<th>EFFECTIVE 1/1/2015 Path B</th>
<th>EFFECTIVE 1/1/2010 Path B</th>
<th>EFFECTIVE 1/1/2015 Path B</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-cooled chillers</td>
<td>≤150 tons</td>
<td>FER (Btu/W)</td>
<td>≥9.562 FL</td>
<td>≥10.100 FL</td>
<td>≥7.900 FL</td>
<td>≥12.500 IPLV</td>
<td>≥13.700 IPLV</td>
<td>≥15.800 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥150 tons</td>
<td>FER (Btu/W)</td>
<td>NA</td>
<td>≥10.100 FL</td>
<td>≥7.900 FL</td>
<td>≥12.750 IPLV</td>
<td>≥14.000 IPLV</td>
<td>≥16.100 IPLV</td>
</tr>
<tr>
<td>All capacities</td>
<td></td>
<td>FER (Btu/W)</td>
<td>Air-cooled chillers without condenser shall be rated with matching condensers and comply with air-cooled chiller efficiency requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-cooled, electrically operated positive displacement</td>
<td>≤75 tons</td>
<td>kW/ton</td>
<td>≤0.780 FL</td>
<td>≤0.780 FL</td>
<td>≤0.780 FL</td>
<td>≤0.630 IPLV</td>
<td>≤0.630 IPLV</td>
<td>≤0.500 IPLV</td>
</tr>
<tr>
<td></td>
<td>&gt;75 tons and ≤150 tons</td>
<td>kW/ton</td>
<td>≤0.775 FL</td>
<td>≤0.720 FL</td>
<td>≤0.750 FL</td>
<td>≤0.615 IPLV</td>
<td>≤0.560 IPLV</td>
<td>≤0.490 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥150 tons and &lt;300 tons</td>
<td>kW/ton</td>
<td>≤0.680 FL</td>
<td>≤0.660 FL</td>
<td>≤0.680 FL</td>
<td>≤0.580 IPLV</td>
<td>≤0.540 IPLV</td>
<td>≤0.440 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥300 tons and &lt;600 tons</td>
<td>kW/ton</td>
<td>≤0.620 FL</td>
<td>≤0.610 FL</td>
<td>≤0.625 FL</td>
<td>≤0.540 IPLV</td>
<td>≤0.520 IPLV</td>
<td>≤0.410 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥600 tons</td>
<td>kW/ton</td>
<td>≤0.620 FL</td>
<td>≤0.639 FL</td>
<td>≤0.585 FL</td>
<td>≤0.540 IPLV</td>
<td>≤0.490 IPLV</td>
<td>≤0.380 IPLV</td>
</tr>
<tr>
<td>Water-cooled, electrically operated centrifugal</td>
<td>≤150 tons</td>
<td>kW/ton</td>
<td>≤0.634 FL</td>
<td>≤0.695 FL</td>
<td>≤0.610 FL</td>
<td>≤0.596 IPLV</td>
<td>≤0.550 IPLV</td>
<td>≤0.440 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥150 tons and &lt;300 tons</td>
<td>kW/ton</td>
<td>≤0.596 IPLV</td>
<td>≤0.610 FL</td>
<td>≤0.635 FL</td>
<td>≤0.596 IPLV</td>
<td>≤0.550 IPLV</td>
<td>≤0.400 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥300 tons and &lt;400 tons</td>
<td>kW/ton</td>
<td>≤0.576 FL</td>
<td>≤0.560 FL</td>
<td>≤0.595 FL</td>
<td>≤0.576 IPLV</td>
<td>≤0.520 IPLV</td>
<td>≤0.390 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥400 tons and &lt;600 tons</td>
<td>kW/ton</td>
<td>≤0.576 FL</td>
<td>≤0.560 FL</td>
<td>≤0.585 FL</td>
<td>≤0.549 IPLV</td>
<td>≤0.400 IPLV</td>
<td>≤0.380 IPLV</td>
</tr>
<tr>
<td></td>
<td>≥600 tons</td>
<td>kW/ton</td>
<td>≤0.570 FL</td>
<td>≤0.590 FL</td>
<td>≤0.585 FL</td>
<td>≤0.539 IPLV</td>
<td>≤0.500 IPLV</td>
<td>≤0.380 IPLV</td>
</tr>
<tr>
<td>Air-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.600 FL</td>
<td>≥0.600 FL</td>
<td>≥0.600 FL</td>
<td>≥0.600 FL</td>
<td>≥0.600 FL</td>
<td>NA</td>
</tr>
<tr>
<td>Water-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.700 FL</td>
<td>≥0.700 FL</td>
<td>≥0.700 FL</td>
<td>≥0.700 FL</td>
<td>≥0.700 FL</td>
<td>NA</td>
</tr>
<tr>
<td>Absorption double effect, indirect fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000 FL</td>
<td>≥1.000 FL</td>
<td>≥1.000 FL</td>
<td>≥1.000 IPLV</td>
<td>≥1.000 IPLV</td>
<td>NA</td>
</tr>
<tr>
<td>Absorption double effect, direct fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000 FL</td>
<td>≥1.000 FL</td>
<td>≥1.000 FL</td>
<td>≥1.000 IPLV</td>
<td>≥1.000 IPLV</td>
<td>NA</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 in accordance with 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 requirements shall be met or exceeded to comply with this appendix. When there is a Path B, compliance shall be permitted to be 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 shall be permitted to be used.

5. FL shall be the full-load performance requirements, and IPLV shall be for the part-load performance requirements.
# TABLE E 503.7.1(4)

**ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS, SINGLE-PACKAGED VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR CONDITIONERS, AND ROOM AIR CONDITIONER HEAT PUMPS - MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1D-4]

<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</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC (cooling mode) Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>[12.5 - (0.213 \times \text{Cap}/1000)] EER (before 10/8/2012) [13.8 - (0.300 \times \text{Cap}/1000)] EER (as of 10/8/2012) (before 1/1/2015) [14.0 - (0.300 \times \text{Cap}/1000)] EER (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 x Cap/1000) [EER]</td>
<td></td>
</tr>
<tr>
<td>PTHP (cooling mode) Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>12.3 - (0.213 x Cap/1000) [EER]</td>
<td></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 x Cap/1000) [EER]</td>
<td></td>
</tr>
<tr>
<td>PTHP (heating mode) Standard Size</td>
<td>All capacities</td>
<td>–</td>
<td>2.2 - (0.026 x Cap/1000) [COP_H] (before 10/8/2012) [3.7 - (0.052 x Cap/1000)] [COP_H] (as of 10/8/2012)</td>
<td></td>
</tr>
<tr>
<td>PTHP (heating mode) Nonstandard Size</td>
<td>All capacities</td>
<td>–</td>
<td>2.9 - (0.026 x Cap/1000) [COP_H]</td>
<td></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>9.0 - 10.0 [EER]</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and ≤135 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.9 - 10.0 [EER]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.6 - 10.0 [EER]</td>
<td></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>9.0 - 10.0 [EER]</td>
<td></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>8.9 - 10.0 [EER]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.6 - 10.0 [EER]</td>
<td></td>
</tr>
<tr>
<td>SPVHP (heating mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 [COP_H]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 [COP_H]</td>
<td></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>2.9 [3.0 [COP_H]</td>
<td></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>SPVAC (cooling mode), nonweatherized space constrained</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>SPVAC (heating mode), nonweatherized space constrained</td>
<td>≤30 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>9.2 EER</td>
<td></td>
</tr>
<tr>
<td>SPVAC (heating mode), nonweatherized space constrained</td>
<td>&gt;30 000 Btu/h and ≤36 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioners, without louvered sides</td>
<td>≤8000 Btu/h</td>
<td>–</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner heat pumps with louvered sides</td>
<td>≥8000 Btu/h and &lt;20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner heat pumps with louvered sides</td>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner, casement only</td>
<td>&lt;14 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner, casement only</td>
<td>≥14 000 Btu/h</td>
<td>–</td>
<td>8.0 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner, casement-slider</td>
<td>All capacities</td>
<td>–</td>
<td>8.7 EER</td>
<td></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 shall be factory labeled as follows: “MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION 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” shall mean the rated cooling capacity of the product in Btu/h (kW). Where 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>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category (Input)</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm air furnace, gas-fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity&lt;sup&gt;3&lt;/sup&gt;</td>
<td>78% AFUE or 80% $E_t^{2,4}$</td>
<td>DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, of CSA Z21.47</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td></td>
<td>80% $E_t^{4}$</td>
<td>Section 2.39, Thermal Efficiency, of CSA Z21.47</td>
</tr>
<tr>
<td>Warm air furnace, oil-fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity&lt;sup&gt;3&lt;/sup&gt;</td>
<td>78% AFUE or 80% $E_t^{2,4}$</td>
<td>DOE 10 CFR Part 430 or Section 42, Combustion, of UL 727</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td></td>
<td>81% $E_t^{4}$</td>
<td>Section 42, Combustion, of UL 727</td>
</tr>
<tr>
<td>Warm air duct furnaces, gas-fired</td>
<td>All capacities</td>
<td>Maximum capacity&lt;sup&gt;3&lt;/sup&gt;</td>
<td>80% $E_c^{5}$</td>
<td>Section 2.10, Efficiency, of CSA Z83.8</td>
</tr>
<tr>
<td>Warm air unit heaters, gas-fired</td>
<td>All capacities</td>
<td>Maximum capacity&lt;sup&gt;3&lt;/sup&gt;</td>
<td>80% $E_c^{5,6}$</td>
<td>Section 2.10, Efficiency, of CSA Z83.8</td>
</tr>
<tr>
<td>Warm air unit heaters, oil-fired</td>
<td>All capacities</td>
<td>Maximum capacity&lt;sup&gt;3&lt;/sup&gt;</td>
<td>80% $E_c^{5,6}$</td>
<td>Section 40, Combustion, of 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 NAECA (three-phase power or cooling capacity greater than or equal to 65 000 Btu/h (19 kW) or more shall be permitted to comply with either rating.
3. Multiple firing rate units shall be at the maximum firing rate.
4. $E_t$ = thermal efficiency. Units shall 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. $E_c$ = combustion efficiency (100 percent less flue losses). See test procedure for detailed discussion.
6. As of August 8, 2008, in accordance with the Energy Policy Act of 2005, units shall also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper. A vent damper is an acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the conditioned space.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY OR RATING CONDITION</th>
<th>SIZE CATEGORY (INPUT)</th>
<th>MINIMUM EFFICIENCY 2, 3</th>
<th>EFFICIENCY AS OF 2/2040 2, 3</th>
<th>EFFICIENCY AS OF 3/2/2020 2, 3</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boilers, hot water</td>
<td>Gas-fired</td>
<td>&lt;300 000 Btu/h 6, 7</td>
<td>80.82% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥300 000 Btu/h and ≤2 500 000 Btu/h 6, 7</td>
<td>80% Et 4</td>
<td>80% Et 4</td>
<td>80% Et 4</td>
<td>10 CFR Part 431</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2 500 000 Btu/h 1</td>
<td>80.82% Ec</td>
<td>82% Ec</td>
<td>82% Ec</td>
<td>10 CFR Part 430</td>
</tr>
</tbody>
</table>

| Boilers, steam | Gas-fired                       | <300 000 Btu/h 6, 7    | 75.80% AFUE              | 75% AFUE                    | 75% AFUE                        | 10 CFR Part 430 |
|                | Gas-fired – except natural draft | ≥300 000 Btu/h and ≤2 500 000 Btu/h 6, 7 | 75.79% Et 4                  | 79% Et 4                   | 79% Et 4                        | 10 CFR Part 431 |
|                |                                | >2 500 000 Btu/h 1     | 84.79% Ec                  | 79% Ec                       | 79% Ec                           | 10 CFR Part 431 |
|                | Gas-fired – natural draft      | ≥300 000 Btu/h and ≤2 500 000 Btu/h 6, 7 | 74.77% Et 4                  | 79% Et 4                   | 79% Et 4                        | 10 CFR Part 431 |
|                |                                | >2 500 000 Btu/h 1     | 84.77% Ec                  | 79% Ec                       | 79% Ec                           | 10 CFR Part 431 |
|                | Oil-fired                      | <300 000 Btu/h 6, 7    | 80.82% AFUE              | 80% AFUE                    | 80% AFUE                        | 10 CFR Part 430 |
|                |                                | ≥300 000 Btu/h and ≤2 500 000 Btu/h 6, 7 | 81.81% Et 4                  | 81% Et 4                   | 81% Et 4                        | 10 CFR Part 431 |
|                |                                | >2 500 000 Btu/h 1     | 83.81% Ec                  | 81% Ec                       | 81% Ec                           | 10 CFR Part 431 |

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 (2344 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. Et = 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-tired (residual).
6. Date three years after ASHRAE Board Approval: Boilers shall not be equipped with a constant burning pilot light.
7. Date thirteen years after ASHRAE Board Approval: 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
[ASHRAE 90.1: TABLE 6.8.1G-7]

| EQUIPMENT TYPE | TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS | SUBCATEGORY OR RATING CONDITION | PERFORMANCE REQUIRED | TEST PROCEDURE
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller or axial fan open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water</td>
<td>≥ 38.2 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan open-circuit cooling towers</td>
<td>All</td>
<td>95°F entering water</td>
<td>≥ 20.0 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water</td>
<td>≥14.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan closed-circuit cooling towers</td>
<td>All</td>
<td>102°F entering water</td>
<td>≥7.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90°F leaving water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan evaporative condensers</td>
<td>All</td>
<td>R-507A test fluid</td>
<td>≥157 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>165°F entering gas temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>105°F condensing temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller or axial fan evaporative condensers</td>
<td>All</td>
<td>Ammonia test fluid</td>
<td>≥134 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>140°F entering gas temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>96.3°F condensing temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan evaporative condensers</td>
<td>All</td>
<td>R-507A test fluid</td>
<td>≥135 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>165°F entering gas temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>105°F condensing temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal fan evaporative condensers</td>
<td>All</td>
<td>Ammonia test fluid</td>
<td>≥110 000 Btu/h·hp</td>
<td>CTI ATC-106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>140°F entering gas temperature</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>96.3°F condensing temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75°F entering wb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air-cooled condensers</td>
<td>All</td>
<td>125°F condensing temperature R-22 test fluid</td>
<td>≥176 000 Btu/h·hp</td>
<td>AHRI 460</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125°F condensing temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>190°F entering gas temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15°F subcooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>95°F entering db</td>
<td></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

Notes:
1. For purposes of this table, open-circuit cooling tower performance shall be 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 rating.
For purposes of this table, closed-circuit cooling tower performance shall be 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.

For purposes of this table, air-cooled condenser performance shall be defined as the heat rejected from the refrigerant divided by the fan motor nameplate power.

ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

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 shall not apply to field-erected cooling towers.

Cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of project-specific accessories, options, or both included in the capacity of the cooling tower.

For purposes of this table, evaporative condenser performance shall be 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.

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 shall be in accordance with the minimum efficiency requirements listed above with R-507A as the test fluid.

### TABLE E 503.7.1(8)
HEAT TRANSFER EQUIPMENT
[ASHRAE 90.1: TABLE 6.8.1M-8]

<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 complete specification of the referenced test procedure, including the referenced year version of the test procedure.

### TABLE E 503.7.1(9)
MINIMUM EFFICIENCY REQUIREMENTS FOR ELECTRICALLY OPERATED VARIABLE-REFRIGERANT-FLOW AIR CONDITIONERS-MINIMUM EFFICIENCY REQUIREMENTS
[ASHRAE 90.1: TABLE 6.8.1I-9]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUB-CATEGORY 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 Multi-split system</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>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>11.2 EER (as of 7/1/2012)</td>
<td>AHRI 1230</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 Multi-split system</td>
<td>11.0 EER (as of 7/1/2012)</td>
<td>12.3 IEER (as of 7/1/2012)</td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>10.0 EER (as of 7/1/2012)</td>
<td>11.1 IEER (as of 7/1/2012)</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUB-CATEGORY OR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VRF Air cooled, (cooling mode)</strong></td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system</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>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>11.0 EER&lt;br&gt;12.3 IEER&lt;br&gt;12.9 IEER (as of 7/1/2012)</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system with heat recovery</td>
<td>10.8 EER&lt;br&gt;12.1 IEER&lt;br&gt;12.7 IEER (as of 7/1/2012)</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 Multi-split system</td>
<td>10.6 EER&lt;br&gt;11.8 IEER&lt;br&gt;12.3 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>9.5 EER&lt;br&gt;10.6 IEER&lt;br&gt;11.0 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system with heat recovery</td>
<td>9.3 EER&lt;br&gt;10.4 IEER&lt;br&gt;10.8 IEER (as of 7/1/2012)</td>
<td></td>
</tr>
<tr>
<td><strong>VRF Water source (cooling mode)</strong></td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems 86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems with heat recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems 86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems with heat recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems 86°F entering water</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems with heat recovery 86°F entering water</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td><strong>VRF Groundwater source (cooling mode)</strong></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 59°F entering water</td>
<td>16.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 59°F entering water</td>
<td>16.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 59°F entering water</td>
<td>13.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 59°F entering water</td>
<td>13.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 77°F entering water</td>
<td>13.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 77°F entering water</td>
<td>13.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 77°F entering water</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 77°F entering water</td>
<td>10.8 EER</td>
<td></td>
</tr>
</tbody>
</table>
For SI units: 1000 British thermal units per hour = 0.293 kW, °C=(°F-32)/1.8

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

Notes:
1 Net sensible cooling capacity: The total gross cooling capacity minus the latent cooling, minus the energy to the air movement system (total gross - latent - fan power)
2 Sensible coefficient of performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions in accordance with ASHRAE 127. The net sensible cooling capacity shall be the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

### TABLE E 503.7.1(11)

**AIR CONDITIONERS AND CONDENSING UNITS SERVING COMPUTER ROOMS**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY</th>
<th>MINIMUM SCOP-127 EFFICIENCY</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>2.20 / 2.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>1.90 / 1.79</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>2.60 / 2.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.40 / 2.29</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled with fluid economizer</td>
<td>&lt;65 000 Btu/h</td>
<td>2.55 / 2.44</td>
<td>ASHRAE 127</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.35 / 2.24</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td>&lt;65 000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.15 / 2.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol with fluid economizer)</td>
<td>&lt;65 000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt; 240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.05 / 1.94</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW
### Table E 503.7.2(1)

**Minimum Duct Insulation R-Value\(^1\) for Cooling and Heating Only Supply Ducts and Return Ducts**

*ASHRAE 90.1: Table 6.8.2A-1*

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DUCT LOCATION</th>
<th>HEATING ONLY DUCTS</th>
<th>COOLING ONLY DUCTS</th>
<th>RETURN DUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EXTERIOR</td>
<td>VENTILATED ATTIC</td>
<td>UNVENTED ATTIC ABOVE INSULATED CEILING</td>
<td>UNVENTED ATTIC WITH ROOF</td>
</tr>
<tr>
<td>1, 2</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td>R-6</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>none</td>
</tr>
<tr>
<td>7</td>
<td>R-8</td>
<td>R-6</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>8</td>
<td>R-8</td>
<td>R-8</td>
<td>R-6</td>
<td>none</td>
</tr>
</tbody>
</table>

#### Notes:

1. Insulation R-values, measured in \(\text{Btu} \cdot \text{in}/(\text{h} \cdot \text{ft}^2 \cdot \degree \text{F})\) or \(\text{W}/(\text{m} \cdot \text{K})\), 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 are used as plenum walls, wall insulation shall be in accordance with the most restrictive condition of Section E 503.4.7.2 or ASHRAE 90.1. 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 crawlspaces, both ventilated and nonventilated.

3. Includes return air plenum, with or without exposed roofs above.

### Table E 503.7.2(2)

**Minimum Duct Insulation R-Value\(^1\) for Combined Heating and Cooling Supply Ducts and Return Ducts**

*ASHRAE 90.1: Table 6.8.2B-2*

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DUCT LOCATION</th>
<th>SUPPLY DUCTS</th>
<th>RETURN DUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EXTERIOR</td>
<td>VENTILATED ATTIC</td>
<td>UNVENTED ATTIC ABOVE INSULATED CEILING</td>
</tr>
<tr>
<td>1</td>
<td>R-6</td>
<td>R-6</td>
<td>R-8</td>
</tr>
<tr>
<td>2</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
</tr>
<tr>
<td>3</td>
<td>R-6</td>
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</tr>
<tr>
<td>4</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
</tr>
<tr>
<td>5</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
</tr>
<tr>
<td>6</td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
</tr>
<tr>
<td>7</td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
</tr>
<tr>
<td>8</td>
<td>R-8</td>
<td>R-8</td>
<td>R-8</td>
</tr>
</tbody>
</table>

#### Notes:

1. Insulation R-values, measured in \(\text{Btu} \cdot \text{in}/(\text{h} \cdot \text{ft}^2 \cdot \degree \text{F})\) or \(\text{W}/(\text{m} \cdot \text{K})\), 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 are used as plenum walls, wall insulation shall be in accordance with the most restrictive condition of Section E 503.4.7.2 or ASHRAE 90.1. 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 crawlspaces, both ventilated and nonventilated.

3. Includes return air plenum, with or without exposed roofs above.
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: 
   \[ T = r \left(1 + \frac{t}{r}K/k - 1\right) \] 
   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 \([\text{Btu}\cdot\text{in}/(\text{h}\cdot\text{ft}^2\cdot\text{°F})]\) \([\text{W}/(\text{m}\cdot\text{K})]\). 
   \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

2 These thicknesses should be based on energy efficiency considerations only. Additional insulation is sometimes permitted to required relative to safety issues/surface temperature.

3 Piping 1½ inches (40 mm) or less and located in partitions within conditioned spaces, reduction of insulation thickness by 1 inch (25.4 mm) shall be permitted before thickness adjustment required in footnote 1, but not a thickness less than 1 inch (25.4 mm).

4 For direct-buried heating and hot water system piping, reduction of insulation thickness by 1½ inch (40 mm) shall be permitted before thickness adjustment required in footnote 1, but not a thickness less than 1 inch (25.4 mm).

5 Table E 503.7.3(2) is based on steel pipe. Non-metallic pipes, less than schedule 80 thickness 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 permitted where documentation is provided showing that the pipe with the proposed insulation has less heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.2(3) 503.7.3(1).

---

### TABLE E 503.7.3(3) 503.7.3(1)

**MINIMUM PIPE INSULATION THICKNESS FOR HEATING AND HOT WATER SYSTEMS**

(Steam, Steam Condensate, Hot Water Heating, and Domestic Water Systems)

[ASHRAE 90.1: TABLE 6.8.3A-1]

<table>
<thead>
<tr>
<th>Fluid Design Operating Temperature Range (°F) and Usage</th>
<th>Insulation Conductivity (Btu·inch/(h·ft²·°F))</th>
<th>Mean Rating Temperature °F</th>
<th>Nominal Pipe Size or Tube Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>105 - 140</td>
<td>0.22 - 0.28</td>
<td>100</td>
<td>1.0</td>
</tr>
<tr>
<td>201 - 250</td>
<td>0.27 - 0.30</td>
<td>150</td>
<td>1.5</td>
</tr>
<tr>
<td>251 - 350</td>
<td>0.29 - 0.32</td>
<td>200</td>
<td>1.5</td>
</tr>
<tr>
<td>&gt;350</td>
<td>0.32 - 0.34</td>
<td>250</td>
<td>5.0</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: 
   \[ T = r \left(1 + \frac{t}{r}K/k - 1\right) \] 
   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 \([\text{Btu}\cdot\text{in}/(\text{h}\cdot\text{ft}^2\cdot\text{°F})]\) \([\text{W}/(\text{m}\cdot\text{K})]\). 
   \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

2 These thicknesses should be based on energy efficiency considerations only. Additional insulation is sometimes permitted to required relative to safety issues/surface temperature.

3 For insulation outside the stated conductivity range, the minimum thickness \(T\) shall be determined as follows: 
   \[ T = r \left(1 + \frac{t}{r}K/k - 1\right) \] 
   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 \([\text{Btu}\cdot\text{in}/(\text{h}\cdot\text{ft}^2\cdot\text{°F})]\) \([\text{W}/(\text{m}\cdot\text{K})]\). 
   \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

4 For insulation outside the stated conductivity range, the minimum thickness \(T\) shall be determined as follows: 
   \[ T = r \left(1 + \frac{t}{r}K/k - 1\right) \] 
   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 \([\text{Btu}\cdot\text{in}/(\text{h}\cdot\text{ft}^2\cdot\text{°F})]\) \([\text{W}/(\text{m}\cdot\text{K})]\). 
   \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

---

### TABLE E 503.7.2(4) 503.7.3(2)

**MINIMUM PIPE INSULATION THICKNESS FOR COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)**

[ASHRAE 90.1: TABLE 6.8.3B-2]

<table>
<thead>
<tr>
<th>Fluid Operating Temperature Range (°F) and Usage</th>
<th>Insulation Conductivity (Btu·inch/(h·ft²·°F))</th>
<th>Mean Rating Temperature °F</th>
<th>Nominal Pipe Size or Tube Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°F - 60°F</td>
<td>0.21 - 0.27</td>
<td>75</td>
<td>0.5</td>
</tr>
<tr>
<td>&lt;40°F</td>
<td>0.20 - 0.26</td>
<td>50</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Notes:
1 For insulation outside the stated conductivity range, the minimum thickness \(T\) shall be determined as follows: 
   \[ T = r \left(1 + \frac{t}{r}K/k - 1\right) \] 
   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 \([\text{Btu}\cdot\text{in}/(\text{h}\cdot\text{ft}^2\cdot\text{°F})]\) \([\text{W}/(\text{m}\cdot\text{K})]\). 
   \(k\) = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

2 These thicknesses should be based on energy efficiency considerations only. Issues such as water, vapor permeability, or surface condensation require vapor retarders or additional insulation.

3 Insulation should not be required for direct-buried cooling system piping.

4 Table E 503.7.2(4) 503.7.3(2) is based on steel pipe. Non-metallic pipes less than schedule 80 thickness 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 heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.2(4) 503.7.3(2).
E 605.1.3 Whole-Building Ventilation. A Mechanical exhaust system, supply system, or combination thereof shall be installed to operate for each dwelling unit to provide continuous whole-building ventilation with outdoor air rate each hour at not less than the rate specified in Section E 605.1.3.1. Table E 605.1.3 or, equivalently, Equation E 605.1.3(1) and Equation E 605.1.3(2), based on the floor area of the conditioned space and number of bedrooms.

Exception. An intermittently operating whole-building mechanical ventilation system shall be permitted where the ventilation rate is in accordance with Section E 605.1.7. The system shall be designed for automatic operation. [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 in accordance with Equation E 605.1.3.1.

\[
Q_{\text{fan}} \; Q_{\text{tot}} = 0.040.03 A_{\text{floor}} + 7.5(N_{\text{br}} + 1) \quad \text{[Equation E 605.1.3.1(1)]}
\]

Where:
- \( Q_{\text{fan}} \) fan flow rate total required ventilation rate, cubic feet per minute (ft\(^3\)/min)
- \( A_{\text{floor}} \) floor area of residence, square foot (ft\(^2\))
- \( N_{\text{br}} \) number of bedrooms; not to be less than one

\[
Q_{\text{fan}} = 0.05 A_{\text{floor}} + 3.5(N_{\text{br}} + 1) \quad \text{[Equation E 605.1.3(2)]}
\]

Where:
- \( Q_{\text{fan}} \) = fan flow rate, ft\(^3\)/min
- \( A_{\text{floor}} \) = floor area, ft\(^2\)
- \( N_{\text{br}} \) = 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\(^2\)

Exception: Whole-building mechanical 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 exists 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, and the Authority Having Jurisdiction determines that window operation is a locally permissible method of providing ventilation. [ASHRAE 62.2:4.1.1]

E 605.1.3.2 Different Occupant Density. Table E 605.1.3.1, Equation E 605.1.3(1), and Equation E 605.1.3.1(2) 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 to be used. [ASHRAE 62.2:4.1.3]

E 605.1.3.3 Alternative Ventilation. Other methods shall be permitted to be used to provide the required ventilation rates (in accordance with Table E 605.1.3) where approved by a licensed design professional. [ASHRAE 62.2:4.1.2]

E 605.1.3.4 Infiltration Credit. Section E 605.1.3 includes a default credit for ventilation provided by infiltration of 2 ft\(^3\)/min per 100 square feet [0.0001 (m\(^3\)/s)/m\(^2\)] of occupiable floor space. For buildings built prior to the application of this appendix, where excess infiltration has been measured using ASHRAE 136, the rates in Section E 605.1.3 shall be permitted to be decreased by half of the excess of the rate calculated from ASHRAE 136 that is above the default rate. [ASHRAE 62.2:4.1.3]

E 605.1.4 System Type. The whole-house 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 whole-building ventilation, the local exhaust airflow shall be permitted to be credited towards the whole-building 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 using a flow hood, flow grid, or other airflow measuring device. 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. The “fan on” switch on a heating or air-conditioning system shall be permitted as an operational control for systems introducing ventilation air through a duct to the return side of an HVAC system. Readily accessible override control shall be provided to the occupant. Local exhaust fan switches and “fan-on” switches shall be permitted as override controls. Controls, including the “fan-on” switch of a conditioning system, shall be appropriately labeled.

Exception: An intermittently operating, whole house mechanical ventilation system shall be permitted to be used where the ventilation rate is adjusted according to the exception to Section E 605.1.7. The system shall be designed so that it operates automatically based on a timer. The intermittent mechanical ventilation system shall operate not less than once per day and must operate not less than 10 percent of the time. [ASHRAE 62.2:4.4]

<table>
<thead>
<tr>
<th>TABLE E 605.1.3.1*</th>
<th>VENTILATION AIR REQUIREMENTS, (cubic foot per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLOOR AREA (ft²)</strong></td>
<td><strong>BEDROOMS</strong></td>
</tr>
<tr>
<td>(&lt;1500)</td>
<td>30, 45, 60, 75, 90, 105, 120, 145</td>
</tr>
<tr>
<td>1501-3000</td>
<td>45, 60, 75, 90, 105, 120, 145</td>
</tr>
<tr>
<td>3001-4500</td>
<td>60, 75, 90, 105, 120, 145, 165</td>
</tr>
<tr>
<td>4501-6000</td>
<td>75, 90, 105, 120, 145, 165</td>
</tr>
<tr>
<td>6001-7500</td>
<td>90, 105, 120, 145, 165</td>
</tr>
<tr>
<td>≥7500</td>
<td>105, 120, 145, 165</td>
</tr>
</tbody>
</table>

For SI units: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.00047 m³/s

* Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.

E 605.1.7 Delivered Ventilation. The delivered ventilation rate shall be calculated as the larger of the total supply or total exhaust and shall be not less than specified in Section E 605.1.3 during each hour of operation.

Exception: The effective ventilation rate of an intermittent system is the combination of its delivered capacity, fractional on-time, cycle time, and the ventilation effectiveness from Table E 605.1.7. The fan flow rate required to achieve an effective ventilation rate that is equivalent to the continuous ventilation requirement shall be calculated from the following equation [ASHRAE 62.2:4.5]:

E 605.1.7 Intermittent Mechanical Ventilation. Whole-building mechanical systems designed to provide intermittent ventilation shall be in accordance with Section E 605.1.7.1 and Section E 605.1.7.2. [ASHRAE 62.2:4.5]

E 605.1.7.1 Intermittent Ventilation. Where mechanical ventilation is provided at least once every three hours by a system of one or more fans, the intermittent mechanical ventilation rate shall be calculated as the larger of the time average supply or exhaust airflow rate and shall be not less than specified in Section E 605.1.3. [ASHRAE 62.2:4.5.1]

E 605.1.7.2 Extended-Cycle Intermittent Ventilation. Where mechanical ventilation is not provided at least once every three hours by a single fan system, the intermittent fan airflow rate (Q_{on}) shall be calculated in accordance with Equation E 605.1.7.2(1). Fan cycle time (T_{CYC}) shall not exceed 24 hours. When the fan airflow rate during the on-cycle varies with time, the time average airflow rate during each hour shall meet or exceed the intermittent mechanical ventilation requirement in accordance with Equation E 605.1.7.2(1).
\[ Q_f = Q_{on} \cdot f \quad Q_{on} \geq Q_{fan} \cdot (\epsilon \cdot f) \]  

[Equation E5.1.7.2(1)]

Where:
- \( Q_f \) = fan airflow rate during the on-cycle
- \( Q_{on} \) = intermittent fan airflow rate during the on-cycle
- \( Q_{fan} \) = continuous mechanical ventilation air requirement (from Table E5.1.3.1 or Equation E5.1.3.1)
- \( T_{cyc} \) = fan cycle time, defined as the total time for one on-cycle and one off-cycle (used in Table E5.1.7)
- \( \epsilon \) = mechanical ventilation effectiveness (from Table E5.1.7.2)
- \( f \) = fractional on-time, defined as the on-time for one cycle divided by the cycle time.

Table E5.1.7.2 also requires the calculation of the required turnover, \( N \), in accordance with the following:

\[ N = 12.8 \cdot Q_{fan} \cdot T_{cyc} / A_{floor} \]  

[Equation E5.1.7.2(2)]

Where:
- \( Q_{fan} \) = mechanical ventilation air requirement (from Table E5.1.3.1 or Equation E5.1.3.1), \( \text{ft}^3/\text{min} \)
- \( T_{cyc} \) = fan cycle time, defined as the total time for one off-cycle and one on-cycle, \( \text{hours} \)
- \( A_{floor} \) = floor area of residence, \( \text{ft}^2 \)

See ASHRAE 24 for an example of this calculation. For values not listed in Table 605.1.7.2, use the next higher value for \( N \) or the next lower value for \( T_{cyc} \) or the next lower value for fractional on-time. Linear interpolation shall be permitted for intermediate fractional on-times. The maximum allowed cycle time shall be 24 hours and the minimum allowed fractional on-time shall be 0.1. [ASHRAE 62.2:4.5.2]
### TABLE E 605.1.7 MECHANICAL VENTILATION EFFECTIVENESS (ε) FOR INTERMITTENT FANS

**Notes:**
1. Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.
2. Interpolation in Table E 605.1.6 is not allowed. For values not listed, use the next higher value for Cycle Time or the next lower value for Fractional On-Time. The maximum allowed cycle time is 24 hours and the minimum allowed fractional on-time is 0.1.

### E 605.1.8 Equivalent Ventilation

A whole-building 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 605.1.8 Restrictions on System Type

Use of certain ventilation strategies is restricted in specific climates as follows. [ASHRAE 62.2:4.6]

#### E 605.1.8.1 Hot, Humid Climates

In hot, humid climates, whole-house mechanical net exhaust flow shall not exceed 7.5 ft³/min per 100 square feet [0.0001 (m³/s)/m²]. (See ASHRAE 62.2 for a listing of hot, humid US climates) [ASHRAE 62.2:4.6.1]

#### E 605.1.8.2 Very Cold Climates

Mechanical supply systems exceeding 7.5 ft³/min per 100 square feet [0.0001 (m³/s)/m²] shall not be used in very cold climates. (See ASHRAE 62.2 for a listing of very cold US climates)

**Exception:** These ventilation strategies are not restricted where the Authority Having Jurisdiction approves the envelope design as being moisture resistant. [ASHRAE 62.2:4.6.2]

---

#### Table E 605.1.7.2

| Fractional On-Time, f | 0.00 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Cycle Time, T, (hours) | 0.00 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 | 1.00 |
| 0.1                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.2                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.3                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.4                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.5                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.6                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.7                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.8                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.9                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 1.0                   | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

#### Table Notes

* Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.
* Interpolation in Table E 605.1.6 is not allowed. For values not listed, use the next higher value for Cycle Time or the next lower value for Fractional On-Time. The maximum allowed cycle time is 24 hours and the minimum allowed fractional on-time is 0.1.
TABLE 1701.0
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 24-2008</td>
<td>Ventilation and Indoor Air Quality in Low-Rise Residential Buildings</td>
<td>Ventilation</td>
<td>E 605.1.7</td>
</tr>
<tr>
<td>ISO 13256-1-1998 (R2012)*</td>
<td>Water-to-Air and Brine-to-Air Heat Pumps - Testing and Rating for Performance</td>
<td>Water-Source Heat Pumps</td>
<td>Table E 502.9, E 503.7.1(2)</td>
</tr>
<tr>
<td>SMACNA 044-2012*</td>
<td>HVAC Air Duct Leakage Test Manual, 2nd Edition</td>
<td>Ducts</td>
<td>E 502.4.3.1, E 503.4.7.2(A), E 503.4.7.2(B)</td>
</tr>
</tbody>
</table>

SUBSTANTIATION:
Appendix E is being revised to correlate with ASHRAE 62.2-2013, ASHRAE 90.1-2013, and ASHRAE 90.2-2007 in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines). Table 1701.0 is being revised as ASHRAE 24 is being deleted in Section E 605.1.7, and to reflect the latest update to ISO 13256-1 standard. Furthermore, SMACNA HVAC Air Duct Leakage Test Manual and IAQ Guideline for Occupied Buildings Under Construction are being revised to show the correct date per SMACNA.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 20   NEGATIVE: 1   NOT RETURNED: 1 Garza

EXPLANATION OF NEGATIVE:
TAYLOR: This entire appendix should be deleted and replaced by a reference to ASHRAE Standard 189.1 which is written more professionally and is more comprehensive.

The TCC has the responsibility to resolve conflicts and achieve correlation among the recommendations of the TCs. The TCC shall have the authority to choose between alternative text recommended by the TC, 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 # 366 resulted in a conflict within this code. In order to correlate language the following Technical Correlating Committee proposed action to the UMC is shown as follows:

E 503.4 Mandatory Provisions. Equipment shown in Table E 503.7.1(1) through Table E 503.7.1(13) 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 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) - (11) (remaining text unchanged)
(12) Table E 503.7.1(12) – Commercial Refrigerators and Freezers.
(13) Table E 503.7.1(13) – Commercial Refrigeration.

(remaining text unchanged)
### TABLE E 503.7.1(12)
**COMMERCIAL REFRIGERATOR AND FREEZER**  
[ASHRAE 90.1: TABLE 6.8.1-12]

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

\[ V = \text{the chiller or frozen compartment volume (ft}^3\text{)} \] in accordance with the home appliance manufacturers standard.

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>APPLICATION</th>
<th>ENERGY USE LIMITS (kWh/day)*</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator with solid doors</td>
<td>Holding temperature</td>
<td>(0.10 \times V + 2.04)</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Refrigerator with transparent doors</td>
<td></td>
<td>(0.12 \times V + 3.34)</td>
<td></td>
</tr>
<tr>
<td>Freezers with solid doors</td>
<td></td>
<td>(0.40 \times V + 1.38)</td>
<td></td>
</tr>
<tr>
<td>Freezers with transparent doors</td>
<td></td>
<td>(0.75 \times V + 4.10)</td>
<td></td>
</tr>
<tr>
<td>Refrigerators/freezers with solid doors</td>
<td></td>
<td>The greater of (0.12 \times V + 3.34) or 0.70</td>
<td></td>
</tr>
<tr>
<td>Commercial refrigerators</td>
<td>Pulldown</td>
<td>(0.126 \times V + 3.51)</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE E 503.7.1(13)
**COMMERCIAL REFRIGERATION-MINIMUM EFFICIENCY REQUIREMENTS**  
[ASHRAE 90.1: TABLE 6.8.1-13]

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

\[ °C = \frac{(°F - 32)}{1.8} \]

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.

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>FAMILY CODE</th>
<th>OPERATING MODE</th>
<th>RATING TEMPERATURE</th>
<th>ENERGY USE LIMITS AS OF 1/1/2012 (kWh/day)</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator with solid doors</td>
<td>VOP.RC.M</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>(0.82 \times TDA + 4.07)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>SVO.RC.M</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>(0.83 \times TDA + 3.18)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>HZO.RC.M</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>(0.35 \times TDA + 2.88)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>VOP.RC.L</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>(2.27 \times TDA + 6.85)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>HZO.RC.L</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>(0.57 \times TDA + 6.88)</td>
</tr>
<tr>
<td>Commercial refrigerators</td>
<td>VCT.RC.M</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>(0.22 \times TDA + 1.95)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>VCT.RC.L</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>(0.56 \times TDA + 2.61)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>SOC.RC.M</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>(0.51 \times TDA + 0.11)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>VOP.SC.M</td>
<td>Vertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>(1.74 \times TDA + 4.71)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>SVO.SC.M</td>
<td>Semivertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>(1.73 \times TDA + 4.59)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>HZO.SC.M</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>(0.77 \times TDA + 5.55)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>HZO.SC.L</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Low temperature</td>
<td>(1.92 \times TDA + 7.08)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>VCT.SC.I</td>
<td>Vertical transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>(0.67 \times TDA + 3.29)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>VCS.SC.I</td>
<td>Vertical solid door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>(0.38 \times V + 0.88)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>HCT.SC.I</td>
<td>Horizontal transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>(0.56 \times TDA + 0.43)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>SVO.RC.L</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>(2.27 \times TDA + 6.85)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>VOP.RC.I</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>(2.89 \times TDA + 8.7)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>SVO.RC.I</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>(2.89 \times TDA + 8.7)</td>
</tr>
<tr>
<td>Freezer with solid doors</td>
<td>HZO.RC.I</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>(0.72 \times TDA + 8.74)</td>
</tr>
<tr>
<td>Refrigerator with solid doors</td>
<td>VCT.RC.I</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>(0.66 \times TDA + 3.05)</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.

2. *TDA* is the total display area of the case (ft) as measured in accordance with AHRI 1200.
(Portions of table not shown remain unchanged)

**TCC COMMITTEE ACTION:** Accept as Submitted

**TCC COMMITTEE STATEMENT:**
Section E 503.4 is being revised to correlate with ASHRAE 90.1-2013 in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).

The following proposed action moves forward as approved by the TCC and supersedes the recommendation from the UMC TC.
SUBMITTER: Jeremy Brown  
NSF International

RECOMMENDATION:
Revise text as follows:

**E 505.1.2 Pipe Materials.** Unless otherwise approved by the Authority Having Jurisdiction, underground and submerged pipe used in geothermal systems shall be polyethylene manufactured from resin compound PE 3408 or PE 4710 that is in accordance with ASTM D3350 with a cell classification of 345564 or 345434. Pipe shall be in accordance with ASTM D3035, or CSA B137.1, or NSF 358-1. Polyethylene fittings shall be in accordance with the requirements in ASTM D3261, ASTM D2683, ASTM F1055, or CSA B137.1, or NSF 358-1. Joints and connections of underground and submerged polyethylene piping shall be heat fused or electrofused. Pipe and fittings shall comply with the applicable requirements for hydronic piping systems in this code.

**TABLE 1701.0**  
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>NSF 358-1-2012*</td>
<td>Polyethylene Pipe and Fittings for Water-Based Ground-Source “Geothermal” Heat Pump Systems.</td>
<td>Miscellaneous</td>
<td>E 505.1.2</td>
</tr>
</tbody>
</table>

Note: NSF 358-1 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’S Regulations Governing Committee Projects.

Note: NSF 358-2 is a working draft and is not completed at the time of this monograph.

(portions of table not shown remain unchanged)

**SUBSTANTIATION:**
NSF 358-1 and NSF 358-2 are American National Standards dealing with polyethylene and polypropylene piping systems used in geothermal applications. The standards deal with physical properties, performance requirements, long-term strength requirements, chemical resistance requirements, and quality control requirements. These standards have additional requirements beyond the ASTM standards referenced that are more specific to geothermal applications.

**COMMITTEE ACTION:** Accept as Amended by the TC
Amend proposal as follows:

**TABLE 1701.0**  
REFERENCED STANDARDS

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
</table>
COMMITTEE STATEMENT:
NSF 358-2 is a working draft, and should not be referenced in the code until completed.

A PUBLIC COMMENT(S) WAS SUBMITTED FOR REVIEW AND CONSIDERATION.
PUBLIC COMMENT:
SUBMITTER: Jeremy Brown, NSF International

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

<p>| TABLE E 505.5  |
| PLASTIC GROUND SOURCE LOOP PIPING |</p>
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
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<tbody>
<tr>
<td>Polypropylene (PP-R)</td>
<td>ASTM F2389; CSA B137.11, NSF 358-2</td>
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</table>

(portions of table not shown remain unchanged)

<p>| TABLE E 505.6  |
| GROUND SOURCE LOOP PIPE FITTINGS |</p>
<table>
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<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polypropylene (PP-R)</td>
<td>ASTM F2389; CSA B137.11, NSF 358-2</td>
</tr>
</tbody>
</table>

(ports of table not shown remain unchanged)

<p>| TABLE 1701.0  |
| REFERENCED STANDARDS |</p>
<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSF 358-2-2012*</td>
<td>Polypropylene Pipe and Fittings for Water-Based Ground-Source &quot;Geothermal&quot; Heat Pump Systems</td>
<td>Miscellaneous</td>
<td>Table E 505.5, Table E 505.6</td>
</tr>
</tbody>
</table>

Note: NSF 358-2 meets the requirements for a mandatory reference standard in accordance with Section 3-3.7.1 of IAPMO’s Regulations Governing Committee Projects.

SUBSTANTIATION:
NSF 358-2 is a complete American National Standard for polypropylene geothermal systems and should be referenced in Appendix E of the UMC. The standard has requirements specific to geothermal applications. The Technical Committee statement is incorrect. NSF 358-2 is completed and was completed during the time of the Technical Committee meeting in Salt Lake City. This was submitted to both IAPMO and the TC.

COMMITTEE ACTION: Accept the public comment as submitted

TOTAL ELIGIBLE TO VOTE: 22

VOTING RESULTS: AFFIRMATIVE: 21 NOT RETURNED: 1 Garza
Technical Correlating Committee Report
IAPMO Technical Correlation Committee (TCC)
Report

PART I – CORRELATION ITEMS BETWEEN THE 2015
UPC/UMC/USEHC/USPSHTC

TCC ITEM 1

<table>
<thead>
<tr>
<th>2015 UNIFORM PLUMBING CODE</th>
<th>2015 UNIFORM MECHANICAL CODE</th>
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</thead>
<tbody>
<tr>
<td>ITEM # 003 (Public Comment 1)</td>
<td>ITEM # 066</td>
</tr>
<tr>
<td><strong>COMMENTS</strong></td>
<td><strong>COMMENTS</strong></td>
</tr>
</tbody>
</table>

**RECOMMENDATION:**

**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.

**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 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

**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 plans and specifications construction documents shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said plans and specifications 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.

**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 plans, diagrams, computations, and other data construction documents 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.
construction documents, computations, and specifications shall be prepared 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 plumbing 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.

### 104.4 Permit Issuance
The application, construction documents, computations, 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

<table>
<thead>
<tr>
<th>Item #003 (Public Comment 1)</th>
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</thead>
<tbody>
<tr>
<td><strong>2015 UNIFORM PLUMBING CODE</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Exception:</strong> 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.</td>
<td></td>
</tr>
<tr>
<td><strong>104.3.2 Plan Review Fees:</strong> 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.</td>
<td></td>
</tr>
<tr>
<td>The plan review fees for plumbing work shall be determined and adopted by this jurisdiction.</td>
<td></td>
</tr>
<tr>
<td>The plan review fees specified in this subsection are separate fees from the permit fees specified in Section 104.5.</td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

### 104.5.1 Plan Review Fees
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 Information on Plans and Specifications
Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall indicate the location, nature, and extent of the work proposed and show in detail that it is in accordance with the provisions of this code and relevant laws, ordinances, rules, and regulations.

The Authority Having Jurisdiction shall have the option to accept plans and specifications electronically, in lieu of on cloth or paper, in whatever format it shall require.
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 plumbing system before the entire construction documents for the whole system have been submitted or approved, provided adequate information and detailed statements have been filed in accordance with the pertinent requirements of this code. The holder of such permit shall be permitted to proceed at the holder’s risk without assurance that the permit for the entire building, structure, or plumbing 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 suspensions or abandonment has not exceeded 1 year.

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 plans and specifications construction documents “APPROVED.” Such approved plans and specifications 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 plans and specifications 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 plans and specifications 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 plans and specifications construction documents for such work, and provided further that such suspension or abandonment has not exceeded 1 year.
104.4.6 Retention of Plans. One set of approved construction documents and computations shall be retained by the Authority Having Jurisdiction until final approval of the work covered therein.

One set of approved construction documents, computations, and manufacturer’s installation instructions shall be returned to the applicant, and said set shall be kept on the site of the building or work at times during which the work authorized thereby is in progress.

E 33.2 Metallic Gas Piping. Metallic gas piping systems shall be installed in accordance with approved construction documents, including provisions for cathodic protection. Each cathodic protection system shall be designed and installed in accordance with the provisions of 49 CFR 192. [NFPA 501A:4.3.7.2.4, 4.3.7.2.7]

205.0 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.

D 11.2 Metallic Gas Piping. 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 in accordance with the provisions of 49 CFR 192. [NFPA 501A:4.3.7.2.1, 4.3.7.2.2]

205.0 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.
RECOMMENDATION:

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 plans and specifications construction documents shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said plans and specifications 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.

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 plans, diagrams, computations, and other data—construction documents 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 Plans and Specifications—Construction Documents. Plans—Construction documents, 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—construction documents, computations, and specifications to be prepared by, and the system designed by, a registered design professional. Construction documents shall be drawn to scale with clarity to identify that the intended work to be performed is in accordance with the code.

Exception: The Authority Having Jurisdiction shall be permitted to waive the submission of plans—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 plans—construction documents is not necessary to obtain compli-

103.3 Applications and Permits. The Authority Having Jurisdiction shall be permitted to require the submission of plans, specifications, drawings, and such other information as required by 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 plans and specifications construction documents shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said plans and specifications 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.

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(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 plans, diagrams, computations, and other data—construction documents 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 Plans and Specifications—Construction Documents. Plans—Construction documents, 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—construction documents, computations, and specifications to be prepared by, and the plumbing 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.

Plans and specifications—Construction documents for indoor installations of public or private swimming pool, spa, hot tub, bathing, aquatic play, or wading facilities
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 plans and specifications, construction documents for review.

The plan review fees for system work shall be determined and adopted by this jurisdiction.

The plan review fees specified in this subsection are separate fees from the permit fees specified in Section 104.5.

Where plans are incomplete or changed so as to require additional review, a fee shall be charged at the rate shown in Table 104.5.

104.3.3 Information on Plans and Specifications. Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall indicate the location, nature, and extent of the work proposed and show in detail that it is in accordance with the provisions of this code and relevant laws, ordinances, rules, and regulations.

The Authority Having Jurisdiction shall have the option to accept plans and specifications electronically, in lieu of on cloth or paper, in whatever format it shall require.

(renumber remaining sections)

104.4 Permit Issuance. The application, plans, and specifications, 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 plans and specifications, construction documents “APPROVED.” Such approved plans and specifications, construction documents shall not be changed, modified, or altered.

shall be submitted to the Authority Having Jurisdiction for approval prior to commencement of work, piping, equipment, or combination thereof. Construction shall be equal to the types prescribed in the installation requirements of the plumbing code.

Exception: The Authority Having Jurisdiction shall be permitted to waive the submission of plans, 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 plans, construction documents is not necessary to obtain compliance within 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 plans and specifications, construction documents for review.

The plan review fees for work to install, alter, or repair a swimming pool, spa, hot tub system, or part thereof 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 Information on Plans and Specifications. Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall indicate the location, nature, and extent of the work proposed and show in detail that it is in accordance with the provisions of this code and relevant laws, ordinances, rules, regulations, and Section 104.3.3.1 through Section 104.3.3.3.

The Authority Having Jurisdiction shall have the option to accept plans and specifications electronically, in lieu of on cloth or paper, in whatever format it shall require.

(renumber remaining sections)

104.4 Permit Issuance. The application, plans, specifications, 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.
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 system before the entire plans and specifications 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 system will be granted.

104.4.2 Validity of Permit. The issuance of a permit or approval of plans and specifications 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 said work, provided no changes have been made or will be made in the original plans and specifications construction documents for such work, and provided further that such suspension or abandonment has not exceeded 1 year.

104.4.6 Retention of Plans. One set of approved plans, specifications, 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 plans, specifications, construction documents, computations, and manufacturer’s installation instructions shall be retained by the Authority Having Jurisdiction until final approval of the work covered therein.

104.4.6 Retention of Plans. One set of approved plans, specifications, construction documents, and computations shall be retained by the Authority Having Jurisdiction until final approval of the work covered therein.

One set of approved plans, specifications, computations, and manufacturer’s installation instructions shall be retained by the Authority Having Jurisdiction until final approval of the work covered therein.
205.0 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.

<table>
<thead>
<tr>
<th>Item # 001</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Item # 002</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

**Substantiation:**

1. The revisions to Sections 103.3, 104.3, 104.3.1, 104.3.2, 104.4, 104.4.1, 104.4.2, 104.4.3, 104.4.6, and D 11.2 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 003 (Public Comment 1) in regards to construction documents. Furthermore, the revisions to Sections 103.3, 104.3, 104.3.1, 104.3.2, 104.4, 104.4.1, 104.4.2, 104.4.3, and 104.4.6 of the USEHC and USPSHTC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 003 (Public Comment 1) in regards to construction documents.

The Committee statement provided by the UPC TC for revising “plans and specifications” to “construction documents” in Item # 003 (Public Comment 1) is as follows:

“This proposed code change updates the administrative requirements by using the proper terminology which is “construction documents,” not “plans and specifications.” The other change is to require a minimum of two sets of documents to be submitted. This is necessary so that the inspection department can have a set for permanent records, while one set is used for field inspections. The requirement is also consistent with the building code which requires a minimum of two sets of plans.

The final change relates to the requirement for construction documents to be submitted by a licensed architect or engineer. There is no exception in any state laws that allow an administrative authority to allow a non-licensed individual to prepare construction documents. This corrects the requirement by stipulating that a licensed engineer or architect must prepare construction documents. In addition, construction documents are required to be drawn to scale. This is also required in state law for licensed architects and engineers.

With the additionally language in Section 103.2.1, Section 103.2.2 becomes redundant. Hence, it is proposed for deletion. Additionally, Section 103.2.2 is archaic in its requirement for plans to be drawn on paper or cloth. Cloth hasn’t been used in the architectural and engineering profession for more than 40 years. Most plans are prepared on the computer using some form of a computer aided design. Certain building departments are allowing plans to be submitted electronically. By striking Section 103.2.2, the administrative authority can accept plans and construction documents either electronically or by hard copy.”

2. The new definition for “construction documents” of the UMC, USEHC, and the USPSHTC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 003 (Public Comment 1).

The term “construction documents” is referenced in Section 104.4.1, Section 402.1.1, Section E 503.3.1(13), Section E 503.6.3.1, Section E 503.6.5.1, Section E 503.6.5.2, Section E 503.6.5.3, Section E 802.1(7), and Section E 803.2 of the UMC without being defined. The definition assists the end user in applying and enforcing this term.

The term “construction documents” is referenced in Section 104.4.1, Section 701.2, and Section 701.3 of the
The term “construction documents” is referenced in Section 104.4.1 of the USPSHTC without being defined. The definition assists the end user in applying and enforcing this term.

The Committee statement provided by the UPC TC for accepting public comment Item # 003 (Public Comment 1) as amended is as follows: “The definition for “construction documents” is being modified as plans and specifications are commonly used as part of construction documents.”

TCC ITEM 2

203.0
**Accepted Engineering Practice.** That which conforms to technical or scientific-based principles, tests, or standards that are accepted by the engineering profession.

**Recommendation:**

- Accept recommendation as submitted.
- Reject the recommendation.

**Substantiation:**

The new definition for “accepted engineering practice” of the UMC and USEHC will correlate with actions taken by the UPC TC to “accept as amended by the TC” Item # 016. Furthermore, it will correlate with the actions taken by the USPSHTC to “accept as submitted” Item # 004.

The definition for “accepted engineering practice” is addressed in Section 309.1, Section 1308.7.5.1, and Section D 13.1 of the UMC without being defined. The proposed definition assists the end user in applying and enforcing this term.

The definition for “accepted engineering practice” is addressed in Section 306.1 of the USEHC without being defined. The proposed definition assists the end user in applying and enforcing this term.
The substantiation provided by the UPC for accepting Item # 016 as submitted is as follows: “The term “accepted engineering practice” is used in Sections 309.1, 501.1, 911.1, 1208.7.5.1, 1314.1, and E 35.1 without being defined. The proposed definition assists the end user in applying and enforcing this term, and is consistent with terminology used in other industry standards.”

Note: The UMC TC voted to reject the request to add the definition for “accepted engineering practices.” The Committee statement provided by the UMC TC for rejecting the public comment (Item # 013) is as follows: “The proposed definition for “accepted engineering practice” has not had a public review as it introduces a new concept which was not included in a related proposal as published in the ROP.”

TCC ITEM 3

RECOMMENDATION:

205.0 Copper Alloy. A homogenous mixture of two or more metals in which copper is the primary component, such as brass and bronze.

The substantiation provided by the UPC for accepting Item # 016 as submitted is as follows: “In Section 1109.2, the term “brass” should be modified to “copper alloy” as it is the terminology being used in the industry. Furthermore, The definition for “copper alloy” should be added to maintain uniformity with NFPA 54.”

The substantiation provided by the UPC for accepting public comment Item # 051 (Public Comment 3) as submitted is as follows: “To maintain uniformity with NFPA, this definition was adopted by the NFPA 54 committee.”
RECOMMENDATION:

205.0 Condensate. The liquid phase obtained from condensation of a particular gas or vapor.

---

Accept recommendation as submitted. | Reject the recommendation.

Substantiation:
The revision to the definition for “condensate” of the UPC, USEHC, and USPSHTC will correlate with actions taken by the UMC to “accept the public comment as amended” Item # 018.

The Committee statement provided by the UMC TC for accepting the public comment (Item # 018) as amended is as follows: “The proposed modification will provide clarity in regards to the definition for “condensate.”
TCC ITEM 5

RECOMMENDATION:

301.2.1 Marking. Each length of pipe and each pipe fitting, trap, fixture, material, and device used in a plumbing system shall have cast, stamped, or indelibly marked on it 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 plumbing and drainage 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.

307.1 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 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.

Substantiation:

The TCC believes that the exception for Section 307.1 of the UMC should not be deleted as it is necessary for clarity as nipples cut in the field are not required to have marking. Therefore, Section 301.2.1 of the UPC, Section 302.1.1 of the USEHC, and Section 302.3 of the USPSHTC should be revised to correlate with the actions taken by the UMC TC Item # 042.
The revisions to Section 307.1 (Marking) of the UMC will correlate with Section 301.2.1 of the UPC, Section 302.1.1 of the USEHC, and Section 302.3 of the USPSHTC in regards to marking requirements for each length of piping.

**Note:** The exception to Section 307.1 of the UMC was proposed to the UMC (Item # 042) and was accepted by the UMC TC. However, the exception to Section 307.1 does not correlate with the UPC, USEHC, or the USPSHTC.

A public comment was submitted to the UMC (Item # 042) to remove the exception from Section 307.1 of the UMC so that it correlates with the UPC, USEHC, and the USPSHTC. However, the public comment was rejected by the UMC TC. The Committee statement provided by the UMC TC for rejecting the public comment is as follows: “The exception is necessary as the current marking requirements are too restrictive and does not take into consideration nipples created from pipe.”

### TCC ITEM 6

#### 301.5.1 Permit Application. The registered design professional shall indicate on the design documents that the plumbing system, or parts thereof, is an alternative engineered design so that it is noted on the construction permit application. The permit and permanent permit records shall indicate that an alternative engineered design was part of the approved installation.

#### 301.5.2 Technical Data. The registered design professional shall submit sufficient technical data to substantiate the proposed alternative engineered design and to prove that the performance meets the intent of this code.

#### 301.5.3 Design Documents. The registered design professional shall provide two complete sets of signed and sealed design documents for the alternative engineered design for submittal to the Authority Having Jurisdiction. The design documents shall include floor plans and a riser diagram of the work. Where appropriate, the design documents shall indicate the direction of flow, pipe sizes, grade of horizontal piping, loading, and location of fixtures and appliances.

#### 301.5.5 Design Review. The Authority Having Jurisdiction shall have the authority to require testing of the alternative engineered design in accordance with Section 301.3.1, including the authority to require an independent review of the design documents by a registered design professional selected by the Authority Having Jurisdiction and at the expense of the applicant.

#### 302.3.1 Permit Application. The registered design professional shall indicate on the design documents that the mechanical system, or parts thereof, is an alternative engineered design so that it is noted on the construction permit application. The permit and permanent permit records shall indicate that an alternative engineered design was part of the approved installation.

#### 302.3.2 Technical Data. The registered design professional shall submit sufficient technical data to substantiate the proposed alternative engineered design and to prove that the performance meets the intent of this code.

#### 302.3.3 Design Documents. The registered design professional shall provide two complete sets of signed and sealed design documents for the alternative engineered design for submittal to the Authority Having Jurisdiction. The design documents shall include floor plans of the work. Where appropriate, the design documents shall indicate location, sizing, and loading of appurtenances, equipment, appliances, and devices.

#### 302.3.5 Design Review. The Authority Having Jurisdiction shall have the authority to require testing of the alternative engineered design in accordance with Section 302.2.1, including the authority to require an independent review of the design documents by a registered design professional selected by the Authority Having Jurisdiction and at the expense of the applicant.
RECOMMENDATION:

302.4.1 Permit Application. The registered design professional shall indicate on the design documents that the system, or parts thereof, is an alternative engineered design so that it is noted on the construction permit application. The permit and permanent permit records shall indicate that an alternative engineered design was part of the approved installation.

302.4.2 Technical Data. The registered design professional shall submit sufficient technical data to substantiate the proposed alternative engineered design and to prove that the performance meets the intent of this code.

302.4.3 Design Documents. The registered design professional shall provide two complete sets of signed and sealed design documents for the alternative engineered design for submittal to the Authority Having Jurisdiction. The design documents shall include floor plans of the work. Where appropriate, the design documents shall indicate location, sizing, and loading of appurtenances, equipment, appliances, and devices.

302.4.5 Design Review. The Authority Having Jurisdiction shall have the authority to require testing of the alternative engineered design in accordance with Section 302.2.1, including the authority to require an independent review of the design documents by a registered design professional selected by the Authority Having Jurisdiction and at the expense of the applicant.

<table>
<thead>
<tr>
<th>x</th>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
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</thead>
</table>

Substantiation:
Sections 302.3.1, 302.3.2, 302.3.3, and 302.3.5 of the UMC are being revised to correlate with the actions taken by the UPC TC to “accept as submitted” Item # 007. Furthermore, it will correlate with the actions taken by the USEHC TC to “accept as submitted” Item # 008.

The substantiation provided by the UPC Item # 007 to accept as submitted is as follows:

“This proposed change is to add a definition and correlate the industry recognized term “registered design professional” with the related terms currently used in the Uniform Plumbing Code (UPC). This same proposal is being submitted for all standards developed by IAPMO. The term “registered design professional” is the accepted term for an architect, engineer, or other professional who is licensed and certified by a state to practice their respective design profession. This is also the term as used and defined in the construction and safety codes adopted by almost all state and local jurisdictions throughout the U.S.

The definition in the International Building Code (IBC), the International Residential Code (IRC), and the California Building Code (CBC) is: **REGISTERED DESIGN PROFESSIONAL** An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

The definition as used in the codes and standards developed by NFPA is: **REGISTERED DESIGN PROFESSIONAL** An individual who is registered or licensed to practice his/her respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

As shown in the proposed change (above), the terms “architect or engineer”, “registered engineer”, “registered
The term “registered design professional” is currently used in UPC Sections 911.1 and E 505.1.1. The change will replace the many different terms used throughout the UPC to describe a registered design professional with the industry accepted term, and by adding the definition will eliminate the need to define the term in many separate sections of the code.”

TCC ITEM 7

<table>
<thead>
<tr>
<th>2015 UNIFORM PLUMBING CODE</th>
<th>2015 UNIFORM MECHANICAL CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEM # 359</td>
<td>ITEM # 066</td>
</tr>
</tbody>
</table>

RECOMMENDATION:

**312.5 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 accordance with Section 312.0 in an approved manner.

**319.5 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.

<table>
<thead>
<tr>
<th>2015 UNIFORM SOLAR ENERGY &amp; HYDRONICS CODE</th>
<th>2015 UNIFORM SWIMMING POOL, SPA, &amp; HOT TUB CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEM # 016</td>
<td>ITEM # 071</td>
</tr>
</tbody>
</table>

RECOMMENDATION:

**306.3 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.

**309.4 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 accordance with Section 309.0 in an approved manner.

| Accept recommendation as submitted. | Reject the recommendation. |

Substantiation:

The TCC feels that the text “or tubing” should also be added to the UPC and the USPSHTC for correlation purposes as it is applicable to the UPC and USPSHTC.

Section 312.5 of the UPC, Section 306.3 of the USEHC, and Section 309.4 of the USPSHTC are being revised to correlate with the actions taken by the UMC TC to “accept the public comment as submitted” Item # 066.

Section 312.5 of the UPC makes reference to Section 312.0 for requirements for inspection, and Section 309.4 of the USPSHTC makes reference to Section 309.0 for requirements for inspections and testing of protectively coated pipes. However, Section 312.0 of the UPC and Section 309.4 of the USPSHTC do not provide requirements for inspection and testing in their respective reference sections. Therefore, referencing Section 312.0 in the UPC and referencing Section
309.0 in the USPSHTC creates confusion for the end user and for the enforcement of the section as the reference sections do not provide any requirements for the inspection and testing of protectively coated piping.

The substantiation provided by the UMC for accepting Item # 066 as submitted is as follows:

"Sections 319.2, 319.3, and 319.4 are being added as they are applicable to hydronic system installations. All other modifications were done to correlate with the 2015 USEHC."

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**TCC ITEM 8**

**RECOMMENDATION:**

<table>
<thead>
<tr>
<th>TABLE 313.1 HANGERS AND SUPPORTS</th>
<th>TABLE 316.2 HANGERS AND SUPPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MATERIALS</strong></td>
<td><strong>TYPES OF JOINTS</strong></td>
</tr>
<tr>
<td>PE-RT</td>
<td>Insert and Compression</td>
</tr>
</tbody>
</table>

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**RECOMMENDATION:**

<table>
<thead>
<tr>
<th>TABLE 307.3 HANGERS AND SUPPORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MATERIALS</strong></td>
</tr>
<tr>
<td>PE-RT</td>
</tr>
</tbody>
</table>

x Accept recommendation as submitted.  
Reject the recommendation.

**Substantiation:**

The revision to Table 316.2 of the UMC will to correlate with the actions taken by the UPC TC to not accept a similar revision made to Table 313.1 of the UPC.
The Committee statement provided by the UMC TC for accepting as amended Item # 065 is as follows: “The modification to Table 316.2 will correlate with similar modifications made to the UPC in regards to hanger and supports for PE-RT piping and tubing.”

However, Public Comment (Item 059) of the UPC failed to achieve 2/3 votes during balloting. Therefore, the reason statement provided by the UMC TC is no longer valid as the similar modifications failed to achieve 2/3 votes.

TCC ITEM 9

507.4 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 watertight pan of corrosion-resistant materials shall be installed beneath the water heater with not less than \(\frac{3}{4}\) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than \(1\frac{1}{2}\) inches (38 mm) in depth.

312.2.1 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 watertight pan of corrosion-resistant materials shall be installed beneath the water heater with not less than \(\frac{3}{4}\) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than \(1\frac{1}{2}\) inches (38 mm) in depth.

305.6 Drainage Pan. Where a water heater, boiler, or thermal storage tank is located in an attic, or in or on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly where damage results from a leaking water heater, boiler, or tank, a watertight pan of corrosion-resistant materials shall be installed beneath the water heater, boiler, or tank, with not less than \(\frac{3}{4}\) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than \(1\frac{1}{2}\) inches (38 mm) in depth.

709.4 Drainage Pan. Where water heating equipment is located in an attic, or in or on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly where damage results from leaking water heater heating equipment, a watertight pan of corrosion-resistant materials shall be installed beneath the water heating equipment with not less than \(\frac{3}{4}\) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than \(1\frac{1}{2}\) inches (38 mm) in depth.

<table>
<thead>
<tr>
<th>Item # 015</th>
<th>2015 UNIFORM SOLAR ENERGY &amp; HYDRONICS CODE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECOMMENDATION:</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>305.6 Drainage Pan.</strong> Where a water heater, boiler, or thermal storage tank is located in an attic, or in or on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly where damage results from a leaking water heater, boiler, or tank, a watertight pan of corrosion-resistant materials shall be installed beneath the water heater, boiler, or tank, with not less than (\frac{3}{4}) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than (1\frac{1}{2}) inches (38 mm) in depth.</td>
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<table>
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<tr>
<th>Item # 068</th>
<th>2015 UNIFORM SWIMMING POOL, SPA, &amp; HOT TUB CODE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECOMMENDATION:</td>
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<tr>
<td><strong>709.4 Drainage Pan.</strong> Where water heating equipment is located in an attic, or in or on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly where damage results from leaking water heater heating equipment, a watertight pan of corrosion-resistant materials shall be installed beneath the water heating equipment with not less than (\frac{3}{4}) of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than (1\frac{1}{2}) inches (38 mm) in depth.</td>
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</table>

| x | Accept recommendation as submitted. | Reject the recommendation. |

Substantiation:

The TCC feels that Section 305.6 of the USEHC and Section 709.4 of the USPSHTC should not be revised to correlate with the UPC and the UMC as the language is necessary for enforcement of the equipment identified in the USEHC and the USPSHTC.
The addition of Section 312.2.1 to the UMC will correlate with the actions taken by the UPC TC to “accept as submitted” Item # 161. Furthermore the revisions to Section 305.6 of the USEHC and Section 709.4 of the USPSHTC will correlate with the action taken by the UPC TC to “accept as submitted” Item # 161.

**Note:** The UMC TC rejected the addition of Section 312.2.1 to the UMC (Item # 051) as water heaters are not within the scope of the UMC. However, water heaters are now addressed within Chapter 12 for hydronic systems. Therefore, it should be added to the UMC to correlate with the UPC.

The Committee statement provided by the UMC TC for rejecting the public comment (Item # 051) is as follows:
“This language is within the purview of the UPC.”

The substantiation provided by the UPC for accepting Item # 161 as submitted is as follows:

1. The current language does not clearly address installations on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly which is the intent of this section of code, and has caused confusion within the industry in regards to the application and enforcement of this section.
2. The depth of the pan is important for ensuring that enough space is provided for the drain connection fitting generally located on the side of the pan.”

The substantiation provided by the USEHC for accepting Item # 015 as submitted is as follows:

“Section 305.6 is being added to correlate with the drainage pan requirements found in the UPC. Section 305.6 will require such installations to be installed with a drainage pan to prevent damage to the structure. There is nothing in the code that prohibits the installation of a liquid containing tank in a location where damage can result to the building structure.”

The substantiation provided by the USPSHTC for accepting Item # 068 as submitted is as follows:

1. The following revisions to Section 709.4 correlate with similar revisions made to the 2015 UPC for water heating equipment drainage pans.
2. The current language does not clearly address installations on an attic-ceiling assembly, floor-ceiling assembly, or floor-subfloor assembly which is the intent of this section of code, and has caused confusion within the industry in regards to the application and enforcement of this section.
3. The depth of the pan is important for ensuring that enough space is provided for the drain connection fitting generally located on the side of the pan.”
RECOMMENDATION:

605.1 Copper or Copper Alloy Pipe, Tubing, and Fittings. Joining methods for copper or copper alloy pipe, tubing, and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.1.1 through Section 605.1.5.

605.1.1 Brazed Joints. Brazed joints between copper or copper alloy pipe or tubing and 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.

605.1.2 Flared Joints. Flared joints for soft copper or copper alloy water tubing shall be made with fittings that are in accordance with the applicable standards referenced in Table 604.1. 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.

605.1.3 Mechanical Joints. Mechanical joints shall include, but are not limited to, compression, flanged, grooved, pressed, and push fit fittings.

605.1.3.2 Pressed Fittings. 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. 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 inserted into the fitting. The joint shall be pressed using the tool recommended by the manufacturer.

605.1.3.3 Push Fit Fittings. 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.

605.1.4 Soldered Joints. Soldered joints between copper or copper alloy pipe or tubing and fittings shall be made in accordance with ASTM B828 with the following sequence of joint formation that forms the joint. Pipe or 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.

1211.3 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 610.1. 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) (remaining text unchanged)

(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. 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 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 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
preparation and operation as follows: measuring and cutting, reaming, cleaning, fluxing, assembly and support, heating, applying the solder, cooling and cleaning. 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 F656. Listed CPVC plastic pipe and fittings shall be clean from dirt and moisture. 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. Heat shall be applied using an air or fuel torch with the flame perpendicular to the pipe or tubing using acetylene or an LP gas. Preheating shall depend on the size of the joint. The flame shall be moved to the fitting cup and alternate between the pipe or tubing and fitting. Solder in accordance with ASTM B32 shall be applied to the joint surfaces until capillary action draws the molten solder into the cup. Solder and fluxes with a lead content that exceeds 0.2 percent shall be prohibited in piping systems conveying potable water. Joint surfaces shall not be disturbed until cool and any remaining flux residue shall be cleaned.

605.1.5 Threaded Joints. 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.

605.2 CPVC Plastic Pipe and Joints. CPVC plastic pipe and fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.2.1 through Section 605.2.3.

605.2.1 Mechanical Joints. Removable and non-removable push fit fittings that employ quick assembly push fit connector shall be in accordance with ASSE 1061.

605.2.2 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, \( \frac{1}{2} \) of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, \( \frac{1}{2} \) 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.

1211.2 Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe. Joints between chlorinated poly (vinyl chloride) (CPVC) pipe or fittings shall be installed in accordance with one of the following methods:

1. Removable and non-removable push fit fittings with an elastomeric O-ring that employ quick assembly push fit connectors listed or labeled 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, \( \frac{1}{2} \) of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, \( \frac{1}{2} \) of an inch (15 mm) through 2 inches (5080 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.
605.10 PEX-AL-PEX Plastic Tubing and Joints. PEX-AL-PEX plastic pipe or tubing and fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.10.1 and Section 605.10.1.1.

605.10.1 Mechanical Joints. Mechanical joints between PEX-AL-PEX tubing and fittings shall include mechanical and compression type fittings and insert fittings with a crimping ring. Insert fittings utilizing a crimping ring shall be in accordance with ASTM F1974 or ASTM F2434. Crimp joints for crimp insert fittings shall be joined to PEX-AL-PEX pipe by the compression of a crimp ring around the outer circumference of the pipe, forcing the pipe material into annular spaces formed by ribs on the fitting.

605.10 PEX. PEX plastic pipe or tubing, or fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.10.1 and Section 605.10.1.1.

605.10.1.1 Butt-Fusion Joints. 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.

605.10.1.2 Electro-Fusion Joints. Electro-fusion joints shall be placed internally by a conductor at the interface of the joint made by embedding the resistance wire in the fitting and supplying with a heat source. 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. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.

605.10.1.3 Socket-Fusion Joints. Socket-fusion joints shall be installed in accordance with ASTM F2620 and shall be made

1211.5 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 removed or labeled 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.

1211.7 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe, tubing, or fittings shall be installed in accordance with ASTM D2657 and one of the following heat fusion methods:

1. Butt-fusion joints shall be installed in accordance with ASTM F2620 and shall be made by heating the squared ends of two pipes, pipe and fitting, or two fittings by holding ends against a heated element. The heated element shall be removed where the proper melt is obtained and joined ends shall be placed together with applied force.

2. Electro-fusion joints shall be heated internally by a conductor at the interface of the joint made by embedding the resistance wire in the fitting and supplying with a heat source. 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. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.

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,
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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.

605.11 Polypropylene (PP) Piping and Joints. PP pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.11.1 through Section 605.11.3.

605.11.1 Heat-Fusion Joints. Heat-fusion joints for polypropylene (PP) pipe and fitting joints shall be installed with socket-type heat-fused polypropylene fittings, fusion outlets, 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.

605.11.2 Mechanical and Compression Sleeve Joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions.

605.11.3 Threaded Joints. PP pipe shall not be threaded. PP transition fittings for connection to other piping materials shall only be threaded by use of copper alloy or stainless steel inserts molded in the fitting.

605.12 PVC Plastic Pipe and Joints. PVC plastic pipe and fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.12.1 through Section 605.12.3.

605.12.1 Mechanical Joints. 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.

605.17.1 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.

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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) (remaining text unchanged)

1211.10 Polypropylene (PP) Pipe. Joints between cross-linked 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 brass copper alloy or stainless steel inserts molded in the fitting.

1211.11 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.

(remaining text unchanged)

1211.13.1 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 brass copper alloy adapter, brass 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.
1208.5.2.3 Copper and Copper Alloy. Copper and copper alloy pipe shall not be used where the gas contains more than an average of 0.3 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.

1208.5.3.2 Copper and Copper Alloy. 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.

1208.5.8.4 Metallic Pipe Fittings (Including Valves, Strainers, Filters). Metallic pipe fittings shall comply with the following:

1. (remaining text unchanged)
2. Fittings used with steel or wrought-iron pipe shall be steel, copper alloy, malleable iron, or cast-iron.
3. Fittings used with copper or copper alloy pipe shall be copper or copper alloy.
4. – (7) (remaining text unchanged)
5. Special fittings such as couplings; proprietary-type joints; saddle tees; gland-type compression fittings; and flared, flareless, or compression-type tubing fittings shall be:
   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.

### Table 1701.1 Referenced Standards

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<td>Joints</td>
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(portions of table not shown remain unchanged)

1308.5.2.3 Copper and Brass Copper Alloy. Copper and brass copper alloy pipe shall not be used where the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet (scf) of gas (0.7 mg/100 L). [NFPA 54:5.6.2.3]

Threaded copper, brass copper alloy, or aluminum alloy pipe shall not be used with gases corrosive to such material. [NFPA 54:5.6.2.4]

1308.5.3.2 Copper and Brass Copper Alloy. Copper and brass 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. [NFPA 54:5.6.3.2]

1308.5.10.4 Metallic Pipe Fittings (Including Valves, Strainers, Filters). Metallic pipe fittings shall comply with the following:

1. (remaining text unchanged)
2. Fittings used with steel or wrought-iron pipe shall be steel, brass, bronze copper alloy, malleable iron, or cast-iron.
3. Fittings used with copper or brass copper alloy pipe shall be copper, brass, or bronze copper alloy.
4. – (7) (remaining text unchanged)
5. 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. [NFPA 54:5.6.8.4]

### Table 1701.1 Referenced Standards

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<td>1211.7(1), (3)</td>
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</table>

(portions of table not shown remain unchanged)
409.3 Copper or Copper Alloy Pipe and Tubing. Joints between copper or copper alloy pipe or tubing and fittings shall be installed in accordance with one of the following methods:

(1) Brazed joints between copper or copper alloy pipe or tubing and 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 407.1. 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) (remaining text unchanged)

(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

304.2 CPVC Plastic Pipe and Joints. CPVC plastic pipe and fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 304.2.1 through Section 304.2.3.

304.2.1 Mechanical Joints. Removable and non-removable push fit fittings that employ a quick assembly push fit connector shall be in accordance with ASSE 1061.

304.2.2 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, ½ of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, ½ of an inch (15 mm) through 2½ inches (60 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. The manufacturer’s instructions and ASTM F402 shall be followed for safe practices.

(remaining text unchanged)
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.

304.1.3 Mechanical Joints. Mechanical joints shall include, but are not limited to, compression, flanged, grooved, pressed, and push fit fittings.

304.1.3.2 Pressed Fittings. 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 joint shall be pressed using the tool recommended by the manufacturer.

304.1.3.3 Push Fit Fittings. 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. The 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 inserted into the fitting. The joint shall be pressed using the tool recommended by the manufacturer.

304.1.4 Soldered Joints. Soldered joints between copper or copper alloy pipe or tubing and 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.

304.1.5 Threaded Joints. Threaded joints for copper or
409.5 Cross-Linked Polyethylene/Aluminum /Cross-Linked Polyethylene (PEX-AL-PEX) Pipe. Joints between cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pipe and fittings shall be installed in accordance with one of the following methods:

(1) Mechanical joints between PEX-AL-PEX pipe and fittings shall include mechanical and compression type fittings and insert fittings with a crimping ring. Insert fittings utilizing a crimping ring shall be in accordance with ASTM F1974 or ASTM F2434. Crimp joints for crimp insert fittings shall be joined to PEX-AL-PEX pipe by the compression of a crimp ring around the outer circumference of the pipe, forcing the pipe material into annular spaces formed by ribs on the fitting.

(2) Electro-fusion joints shall be assembled in accordance with ASTM F1290 and shall be made by embedding the resistance wire in the fitting and supplying with a heat source. The joint shall fuse together and remain undisturbed until cool. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.

(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) (remaining text unchanged)

409.7 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe or tubing and fittings shall be installed in accordance with one of the following methods:

(1) Butt-fusion joints shall be installed in accordance with ASTM F2620 and shall be made by heating the squared ends of two pipes, pipe and fitting, or two fittings by holding ends against a heated element. The heated element shall be removed where the proper melt is obtained and joined ends shall be placed together with applied force.

(2) Electro-fusion joints shall be heated internally by a conductor at the interface of the joint and shall be made by embedding the resistance wire in the fitting and supplying with a heat source. The joint shall fuse together and remain undisturbed until cool. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.

(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) (remaining text unchanged)

304.10 PEX-AL-PEX Plastic Tubing and Joints. PEX-AL-PEX plastic pipe or tubing and fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 304.10.1 and Section 304.10.1.1.

304.10.1 Mechanical Joints. Mechanical joints between PEX-AL-PEX tubing and fittings shall include mechanical and compression type fittings and insert fittings with a crimping ring. Insert fittings utilizing a crimping ring shall be in accordance with ASTM F1974 or ASTM F2434. Crimp joints for crimp insert fittings shall be joined to PEX-AL-PEX pipe by the compression of a crimp ring around the outer circumference of the pipe, forcing the pipe material into annular spaces formed by ribs on the fitting.

304.6 PE Plastic Pipe/Tubing and Joints. PE plastic pipe or tubing and-fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 304.6.1 and Section 304.6.2.

304.6.1 Heat-Fusion Joints. Heat-fusion joints between PE pipe or tubing and fittings shall be assembled in accordance with Section 304.6.1.1 through Section 304.6.1.3 using butt, socket, and electro-fusion heat methods in accordance with ASTM D2657.

304.6.1.1 Butt-Fusion Joints. 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.

304.6.1.2 Electro-Fusion Joints. Electro-fusion joints shall be heated internally by a conductor at the interface of the joint made by embedding the resistance wire in the fitting and supplying with a heat source. The joint shall fuse together and remain undisturbed until cool. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion.

304.6.1.3 Socket-Fusion Joints. Socket-fusion joints shall be installed in accordance with ASTM F2620 and
409.10 Polypropylene (PP) Pipe. Joints between polypropylene pipe and fittings shall be installed in accordance with one of the following methods:

1. Heat-fusion joints for polypropylene (PP) pipe shall be installed with socket-type heat-fused polypropylene fittings, butt-fusion polypropylene fittings or pipe, or electro-fusion polypropylene fittings. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F2389 or CSA B137.11.

2. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions. Polypropylene pipe shall not be threaded. Polypropylene transition fittings for connection to other piping materials shall only be threaded by use of copper or copper alloy or stainless steel inserts molded in the fitting.

409.11 Polyvinyl Chloride (PVC) Pipe. Joints between polyvinyl chloride pipe and fittings shall be installed in accordance with one of the following methods:

1. Mechanical joints shall be designed to provide a permanent seal and shall be of the mechanical or push-on joint. The mechanical joint shall include a pipe spigot that has a wall thickness to withstand without deformation or collapse; the compressive force exerted where the fitting is tightened. The push-on joint shall have a minimum wall thickness of the bell at any point between the ring and the pipe barrel. The elastomeric gasket shall comply with ASTM D3139, and be of such size and shape as to provide a compressive force against the spigot and socket after assembly to provide a positive seal.

2. Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Pipe shall be cut square and pipe shall be deburred. Where surfaces to be joined are cleaned and free of dirt, moisture, oil, and other foreign material, apply primer purple in color in accordance with ASTM F656. Primer shall be applied until the surface of the pipe and fitting is softened. Solvent cements in accordance with ASTM D2564 shall be applied to all joint surfaces. Joints shall be made while both the inside socket surface and outside surface of pipe are wet with solvent cement. Hold joint in place and undisturbed for 1 minute after assembly. The manufacturer’s instructions and ASTM F402 shall be followed for safe practices.

3. (remaining text unchanged)

304.11 Polypropylene (PP) Piping and Joints. PP pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 304.11.1 through Section 304.11.3.

304.11.1 Heat-Fusion Joints. Heat-fusion joints for polypropylene (PP) pipe and fitting joints shall be installed with socket-type heat-fused polypropylene fittings, fusion outlets, 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.

304.11.2 Mechanical and Compression Sleeve Joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer’s installation instructions.

304.11.3 Threaded Joints. PP pipe shall not be threaded. PP transition fittings for connection to other piping materials shall only be threaded by use of brass copper alloy or stainless steel inserts molded into the fitting.

304.12 PVC Plastic Pipe and Joints. PVC plastic pipe and fitting joining methods shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 304.12.1 through Section 304.12.3.

304.12.1 Mechanical Joints. 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.

304.12.2 Solvent Cement Joints. Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Pipe shall be cut square and pipe shall be deburred. Where surfaces to be joined are cleaned and free of dirt, moisture, oil, and other foreign material, apply primer purple in color in accordance with ASTM F656. Primer shall be applied until the surface of the pipe and fitting is softened. Solvent cements in accordance with ASTM D2564 shall be applied to all joint surfaces. Joints shall be made while both the inside socket surface and outside surface of pipe are wet with solvent cement. Hold joint in place and undisturbed for 1 minute after assembly.
409.13.1 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 brass copper alloy adapter, brass 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.

703.5.1.1Joining Methods for Polyethylene Pipe or Tubing. Joints between polyethylene (PE) plastic pipe or tubing and fittings shall be installed in accordance with the manufacturer’s installation instructions, and one of the following heat fusion methods:

(1) (remaining text unchanged)

(2) (remaining text unchanged)

(3) 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.

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<td>ASTM F2620-2012*</td>
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<td>ASTM F1290-1998(R2011)*</td>
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(portions of table not shown remain unchanged)

304.14.1 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 brass copper alloy adapter, brass 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.

(portions of table not shown remain unchanged)
Substantiation:

1. The revisions to Sections 605.6.1, 605.6.1.1, 605.6.1.2, and 605.6.1.3 of the UPC will correlate with the actions taken by the USEHC TC to “accept as submitted” Item # 013. Section 605.6.1 of the UPC makes reference to ASTM D2657 which is the incorrect standard for polyethylene as it is applicable to polyolefin. The revisions to Section 605.6.1.1 and Section 605.6.1.3 of the UPC makes reference to ASTM F2620 to correlate with the USEHC as ASTM F2620 is the appropriate standard for heat fusion joining of polyethylene pipe and fittings. The revision to 605.6.1.2 is being revised to correlate with Section 703.5.1.1 (Item # 115) of the USEHC in regards to the joining methods of PE pipe using electro-fusion joints.

2. Section 1211.3, Section 1211.10(2), Section 1211.13.1, Section 1308.5.2.3, Section 1308.5.3.2, and Section 1308.5.10.4 are being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 051 in regards to the use of copper alloy. The revisions to Sections 1211.2, 1211.3, 1211.5, 1211.7, 1211.10, 1211.11, and 1211.13.1 of the UMC will correlate with the actions taken by the USEHC TC to “accept as submitted” Item # 043. Section 1211.7 of the UMC is being revised to correlate with the USEHC as it makes reference to ASTM D2657 which is the incorrect standard for polyethylene which is applicable to only polyolefin. The revisions to Section 1211.7(1) and Section 1211.7(3) of the UMC makes reference to ASTM F2620 to correlate with the USEHC as ASTM F2620 is the appropriate standard for heat fusion joining of polyethylene pipe and fittings. Section 1211.2(2) is being revised by adding reference to ASTM F442 to correlate with the action taken by the UPC TC to “accept as submitted” Item # 196. Furthermore, the pipe sizing requirements in Section 1211.2(2) of the UMC are being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 196. All other modifications were done to correlate with similar sections of the UPC. The revision to Section 1211.7(2) is being revised to correlate with Section 703.5.1.1 (Item # 115) of the USEHC in regards to the joining methods of PE pipe using electro-fusion.

3. Section 409.3, Section 409.10, and 409.13.1 of the USEHC are being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 051 in regards to the use of copper alloy. Section 409.2(2) is being revised by adding reference to ASTM F442 to correlate with the action taken by the UPC TC to “accept as submitted” Item # 196. References to ASTM F402 are being removed from Section 409.2(2) and 409.11(2) to correlate with the actions taken by the UPC TC to “accept the public comment as submitted” Item # 197 and with the actions taken by the UMC TC for Item # 315. Furthermore, the pipe sizing requirements in Section 409.2(2) of the USEHC is being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 196. All other modifications were done to correlate with similar sections of the UPC. The revision to Section 409.7(2) is being revised to correlate with Section 703.5.1.1 (Item # 115) of the USEHC in regards to the joining methods of PE pipe using electro-fusion.

4. The revisions to Sections 304.6.1, 304.6.1.1, 304.6.1.2, and 304.6.1.3 of the USPSHTC will correlate with the actions taken by the USEHC TC to “accept as submitted” Item # 013. Section 304.6.1 of the USPSHTC makes reference to ASTM D2657 which is the incorrect standard for polyethylene as it is applicable to polyolefin. The revisions to Section 304.6.1.1 and Section 304.6.1.3 of the USPSHTC makes reference to ASTM F2620 to correlate with the USEHC as ASTM F2620 is the appropriate standard for heat fusion joining of polyethylene pipe and fittings. Furthermore, the pipe sizing requirements in Section 304.2.2 of the USPSHTC is being revised to correlate with the action taken by the UPC TC to “accept the public comment as submitted” Item # 196. The revision to Section 304.6.1.2 is being revised to correlate with Section 703.5.1.1 (Item # 115) of the USEHC in regards to the joining methods of PE pipe using electro-fusion. All other modifications were done to correlate with similar sections of the UPC.

The substantiation provided by the UPC for accepting Item # 051(Public Comment 2) is as follows: “In order to correlate throughout the UPC, the text “brass” or “bronze” needs to be replaced with “copper alloy” within the proposed sections. This change will correlate the UPC with terminology that is used within industry standards.”
The substantiation provided by the UPC for accepting Item # 196 is as follows: “CPVC listed to ASTM F442 is commonly used in both sprinkler and plumbing systems. ASTM F442 is also recognized within Table 604.1 as an approved standard for CPVC pipe.”

The substantiation provided by the UPC for accepting the public comment (Item # 196) as submitted is as follows: “ASTM F442 CPVC pipe is used in fire sprinkler piping, which is sized up to 3” for a one-step solvent cement. ASTM D2846 tubing is only used with a one-step solvent cement up to 2,” so these products need to be addressed separately.”

The substantiation provided by the UPC for accepting the public comment (Item # 197) is as follows:
1. “The provisions are redundant in the fact that Section 309.4 (Installation Practices) already requires the manufacturer’s installation instructions to be followed for a plumbing system installation.”
2. “ASTM F402 indicates that the specific safety information for handling solvent cement should be obtained from the container label or Material Safety Data Sheet that are both available from the manufacturer. Therefore, if such information is available from the manufacturer then there really is not a compelling reason for referencing ASTM F402.”

The substantiation provided by the USEHC for accepting Item # 115 is as follows: “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 through the use of 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 recommended for underground and indoor piping.”

TCC ITEM 11

RECOMMENDATION:

608.5 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.

1006.2 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 downward.
(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.
315.3 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall have no valves, obstructions or means of isolation and be provided with the following:

1. 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.
x | Accept recommendation as submitted. | Reject the recommendation.
---|---|---

**Substantiation:**
The revision to Section 1006.2 and Section 1206.3 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 207.03. Furthermore, Section 315.3 of the USEHC is being revised to correlate with the actions taken by the UPC TC to “accept the public comment as amended” Item # 207.03.

The Committee Statement provided by the UPC TC for accepting the public comment Item # 207.03 as amended is as follows: “The proposed modification will clarify the intent of the section in regards to the discharge pipe that should run independently and prohibits relief valve discharge into a water heater pan.”
**PART II – CORRELATION ITEMS BETWEEN THE 2015 UPC and UMC**

**TCC ITEM 12**

<table>
<thead>
<tr>
<th>2015 UNIFORM PLUMBING CODE</th>
<th>2015 UNIFORM MECHANICAL CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEM # 165</td>
<td>ITEM # 182</td>
</tr>
<tr>
<td><strong>RECOMMENDATION:</strong></td>
<td></td>
</tr>
</tbody>
</table>

**203.0**

**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).

**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).

| X | Accept recommendation as submitted. | Reject the recommendation. |

**Substantiation:**

The new definitions for “appliance, low-heat” and “appliance, medium-heat” added to the UPC will correlate with the actions taken by the UMC TC to accept the public comment as amended Item # 182. The definitions for “appliance, low-heat” and “appliance, medium-heat” are necessary as they are within the scope of UL 959 and they are referenced within Chapter 5 without being defined. Furthermore, the proposed definitions assist the end user in applying and enforcing these terms.

The Committee statement provided by the UMC TC for accepting Item # 182 as amended is as follows: “In Section 801.2, the text “and medium-heat” should be added as medium-heat appliances are within the scope of Chapter 8 and UL 959. Furthermore, the definitions for “appliance, low-heat” and “appliance, medium-heat” are necessary as they are referenced within Chapter 8 without being defined. The proposed definitions assist the end user in applying and enforcing these terms.”
TCC ITEM 13

**RECOMMENDATION:**

**509.1.1 Listing.** Type B and Type B-W gas vents shall comply with UL 441, and Type L gas vents shall comply with UL 641.

**802.1.1 Listing.** Type B and Type B-W gas vents shall comply with UL 441, and Type L gas vents shall comply with UL 641, and special gas vents shall comply with UL 1738.

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1738-2010*</td>
<td>Venting Systems for Gas-Burning Appliances, Categories II, III, and IV (with revisions through May 13, 2011)</td>
<td>Fuel Gas</td>
<td>103.1, 306.1</td>
</tr>
</tbody>
</table>

(portions of table not shown remain unchanged)

<table>
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<tbody>
<tr>
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</table>

**Substantiation:**

The revision to Section 802.1.1 of the UMC will correlate with the actions taken by the UPC TC to “accept the public comment as submitted” Item # 163. The revision to section 509.1.1 of the UPC will correlate with the actions taken by the UMC TC to “accept the public as amended” Item # 190.

The substantiation provided by the UPC (Item # 163) for modifying Section 509.1.1 (Listing) is as follows:

1. “The UPC only contains provisions for Category I venting systems for water heaters as indicated throughout Section 510.0 (Sizing of Category I Venting Systems) and all of the sizing tables [Table 510.1.2(1) through Table 510.2(9)]. Furthermore, that is why Section 506.1.1 (Other Types of Appliances) requires appliances other than natural draft or Category I to be provided with combustion, ventilation, and dilution air in accordance with the manufacturer’s instructions; this is because Chapter 5 does not contain provisions for Categories II, III, and IV venting systems.”

2. “If UL 1738 is referenced in Chapter 5, it will conflict with the actions of the UPC Technical Committee (TC) during the 2012 code cycle, where the TC made a concerted effort to delete sections of the code that pertained to Categories II, III & IV venting systems [Section 510.1.1 (Categories), Section 510.6.3.2 (Category II, Category III, and Category IV Appliances), and Section 510.11 (Vent Connectors for Category II, Category III, and Category IV Appliances)].”

The substantiation provided by the UMC (Item # 190) for removing UL 1738 from Section 802.1.1 (Listing) is as follows: “Section 802.1.1 is being revised as UL 441 only applies to Type B and Type B-W gas vents, and UL 641 only applies to Type L gas vents. Furthermore, Table 802.4 indicates that venting systems used for Categories II, III, and IV appliances shall be in accordance with the manufacturer’s instructions; therefore, UL 1738 should be deleted as it only applies to Category II, III, and IV appliances.”

Note: Item # 190 was modified by the UMC TC; the Committee statement provided by the UMC TC for accepting the public comment Item # 190 as amended is as follows: “The proposed modification will put back the reference to UL 1738 as it is necessary for enforcement purposes and to provide clarity in regards to the listing of special gas vents.”
TCC ITEM 14

<table>
<thead>
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<th>2015 UNIFORM PLUMBING CODE</th>
<th>2015 UNIFORM MECHANICAL CODE</th>
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<tbody>
<tr>
<td><strong>ITEM # 165</strong></td>
<td><strong>ITEM # 183.01</strong></td>
</tr>
<tr>
<td><strong>COMMENTS</strong></td>
<td><strong>COMMENTS</strong></td>
</tr>
</tbody>
</table>

**RECOMMENDATION:**

**509.5.4.3(A) Decorative Shrouds.** Decorative shrouds addressed in Section 509.5.4.3 shall comply be listed or labeled in accordance with UL 103 for factory-built residential chimneys.

**802.5.1.1 Decorative Shrouds.** Decorative shrouds addressed in Section 802.5.4.3 shall comply 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.

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<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
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</table>

**Substantiation:**

The addition of Section 509.5.4.3(A) to the UPC will correlate with actions taken by the UMC TC to “accept the public comment as submitted” Item # 183.01. The text “be listed and labeled” in the UMC should be replaced to be consistent with terminology being used throughout the code. There is no need to cite “listed or labeled” throughout the code as such requirements are already addressed in Section 306.1. However, the TCC feels that the term “listed or labeled” in the UMC should not be revised as it is needed for emphasis and clarity. Therefore, Section 509.5.4.3(A) of the UPC should be revised accordingly with the language “listed or labeled” included.

**Note:** The UPC rejected the language pertaining to decorative shrouds as it was out of the scope of the UPC. However, not the entire language in Section 509.5.4.3(A) is out of the scope of the UPC as factory-built residential chimneys are addressed within Section 509.5. Therefore, only the language pertaining to factory-built residential chimneys should be added to the UPC to correlate with the UMC.

The substantiation provided by the UMC for accepting the public comment (Item # 183.01) as submitted is as follows: “UL 103 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built chimneys for residential-type and building heating appliances. UL 127 includes a comprehensive set of construction and performance requirements that are used to evaluate and list factory-built fireplaces and includes the chimney requirements. UL 1482 includes a comprehensive set of construction and performance requirements that are used to evaluate and list solid-fuel type room heaters and includes the chimney requirements.”

The Committee statement provided by the UPC TC for rejecting Item # 165 is as follows: “This proposed change is outside the scope of the UPC. It is more applicable to the Uniform Mechanical Code.”
### TCC ITEM 15

**RECOMMENDATION:**

**509.12.1 Listing.** Automatically operated vent dampers for oil-fired appliances shall comply with UL 17. The automatic damper control shall comply with UL 378.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>188</td>
<td></td>
</tr>
</tbody>
</table>

**Substantiation:**

The addition of Section 509.12.1 to the UPC will correlate with the action taken by the UMC TC to “accept as submitted” Item # 188.

The substantiation provided by the UMC for accepting Item # 188 as submitted is as follows:

“Section 802.14.1 will add clarity for the listing requirements of automatically operated vent dampers. UL 17 includes a comprehensive set of construction and performance requirements that are used to evaluate and list these products. UL 378 includes a comprehensive set of construction and performance requirements that are used to evaluate controls for such dampers. These standards are currently listed in Table 1701.0.”

### TCC ITEM 16

**RECOMMENDATION:**

**TABLE 510.1.2(6)**

<table>
<thead>
<tr>
<th>Exterior Masonry Chimney</th>
<th>NFPA 54: Table 13.1(f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(portions of table not shown remain unchanged)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2. NA: Not applicable.

**TABLE 510.2(7)**

<table>
<thead>
<tr>
<th>Exterior Masonry Chimney</th>
<th>NFPA 54: Table 13.2(g)</th>
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<tbody>
<tr>
<td>(portions of table not shown remain unchanged)</td>
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</tr>
</tbody>
</table>

**Notes:**

1. See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2. NA: Not applicable.

**TABLE 803.1.2(6)**

<table>
<thead>
<tr>
<th>Exterior Masonry Chimney</th>
<th>NFPA 54: Table 13.1(f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(portions of table not shown remain unchanged)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2. NA: Not applicable.

**TABLE 803.1.2(13)**

<table>
<thead>
<tr>
<th>Exterior Masonry Chimney</th>
<th>NFPA 54: Table 13.2(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(portions of table not shown remain unchanged)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. See Figure 510.1.2(6) for a map showing local 99 percent winter design temperatures in the United States.
2. NA: Not applicable.
G 3.4 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-vented 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 this exterior masonry chimney need to be relined? Where so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended? [See Table G 3.3 and Figure 510.1.2(6)]

(remaining text unchanged)

F 2.4 Example 5(c): Common Venting into an Exterior Masonry Chimney. In this case, the water heater and fan-assisted furnace of Example 5(a) and Example 5(b) are to be common-vented 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 this exterior masonry chimney need to be relined? Where so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended? [See Table F 2.3 and Figure 803.1.2(6)]

(remaining text unchanged)

<table>
<thead>
<tr>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
</tr>
</thead>
</table>

Substantiation:
The revision to Table 803.1.2(6), Table 803.1.2(13), Table 803.1.2(15), and Section F 2.4 will correlate with the UPC in regards to the winter design temperature. Furthermore, it will correlate with NFPA 54-2012.
TCC ITEM 17

604.2 Copper or Copper Alloy Tube. Copper or copper alloy tube for water piping shall have a weight of not less than Type L.

Exception: Type M copper or copper alloy tubing shall be permitted to be used for water piping where piping is aboveground in, or on, a building or underground outside of structures.

604.3 Hard-Drawn Copper or Copper Alloy Tubing. Hard-drawn copper or copper alloy tubing for water supply and distribution in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

605.1 Copper or Copper Alloy Pipe, Tubing, and Joints. Joining methods for copper or copper alloy pipe, tubing, and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.1.1 through Section 605.1.5.

605.1.1 Brazed Joints. Brazed joints between copper or copper alloy pipe or tubing and 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.

605.1.3 Mechanical Joints. Mechanical joints shall include, but are not limited to, compression, flanged, grooved, pressed, and push fit fittings.

605.1.3.1 Mechanically Formed Tee Fittings. 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.

605.1.3.2 Steel and Copper. Steel and copper tubing, in addition to being Type K, L, or M copper tubing, shall be specified and used in accordance with the plumbing installation instructions provided by the manufacturer.

605.2 Copper Tube. Copper tubing shall have a weight of not less than Type L.

Exception: Type M copper tubing shall be permitted to be used where piping is aboveground in, or on, a building or underground outside of structures.

605.3 Hard-Drawn Copper Tubing. Hard-drawn copper tubing for water supply and distribution, in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

605.4 Copper and Copper Alloy Pipe, Tubing, and Joints. Joining methods for copper and copper-alloy pipe, tubing, and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 605.1.1 through Section 605.1.5.

315.0 Plumbing Connections.
315.1 Pipe, Tube, and Fittings General. Water supply, sanitary drainage, and backflow protection shall be in accordance with the plumbing code. Pipe, tube, and fittings used as supply, drain, hydronics, blowdown, overflow, relief, condensate, or other similar systems shall be of material approved for such use and shall be rated for the operating temperatures and pressures of the system.

315.2 Copper Tube. Copper tube shall have a weight of not less than Type L.

Exception: Type M copper tubing shall be permitted to be used where piping is aboveground in, or on, a building or underground outside of structures.

315.3 Hard-Drawn Copper Tubing. Hard-drawn copper tubing for water supply and distribution, in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

316.0 Copper and Copper Alloy Joints and Connections.
316.1 Copper and Copper Alloy Pipe and Joints. Joining methods for copper and copper-alloy pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 316.1.1 through Section 316.1.3.

316.1.1 Brazed Joints. Brazed joints between brass pipe and fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). 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. An approved brazing flux shall be applied to the joint surfaces where required by manufacturer’s recommendation. The joint shall be brazed with a brazing filler metal in accordance with AWS A5.8. Brazing filler metal shall be applied at the point where the pipe or tubing enters the socket of the fitting.

316.1.2 Mechanical Joints. Mechanical joints shall be installed in accordance with the manufacturer’s installation instructions. Joints shall include compression, flanged, grooved, press, and threaded.

316.1.3 Threaded Joints. Threads shall comply with ASME B1.20.1. Pipe joint compound or tape shall be applied on the male threads only.

316.2 Copper Pipe, Tubing, and Fittings. Joints between copper or copper-alloy pipe, tubing, and fittings...
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 $\frac{1}{4}$ 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.

**605.1.3.2 Pressed Fittings.** 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. 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 inserted into the fitting. The joint shall be pressed using the tool recommended by the manufacturer.

**605.1.3.3 Push Fit Fittings.** Removable and nonremovable push fit fittings for copper or copper alloy pipe or tubing 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 fitting shall be fully inserted into the fitting, and the fitting 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.

**605.1.4 Soldered Joints.** Soldered joints between copper or copper alloy pipe or tubing and fittings shall be made in accordance with ASTM B813, and shall be noncorrosive and nontoxic after cleaning, fluxing, assembly and support, heating, applying the solder, cooling and cleaning. 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 be 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. Heat shall be applied using an air or fuel torch with the flame perpendicular to the pipe or tubing using acetylene or an LP gas. Preheating shall depend on the size of the joint. The flame shall be moved to the fitting cup and alternate between the pipe or tubing and fitting. Solder in accordance with ASTM B32 shall be applied to the joint surfaces until capillary action draws the molten solder into the cup. Solder and fluxes with a lead content that exceeds 0.2 percent shall be prohibited in piping systems conveying potable water. Joint surfaces shall not be disturbed until cool and any remaining flux residue shall be cleaned.

**605.1.5 Threaded Joints.** Threaded joints for copper or copper

<table>
<thead>
<tr>
<th>ITEM #</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>063</td>
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</tr>
<tr>
<td># 3</td>
<td>Connect Joint</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>ITEM #</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>316</td>
<td>2015 UNIFORM MECHANICAL CODE</td>
</tr>
<tr>
<td># 316</td>
<td>shall comply with Section 316.2.1 through Section 316.2.3.</td>
</tr>
</tbody>
</table>

**316.2.1 Brazed joints.** Brazed joints between copper pipe or tubing and fittings shall be made with brazing alloys having a liquid temperature above 1000°F (538°C). 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. An approved brazing flux shall be applied to the joint surfaces where required by manufacturer’s recommendation. The joint shall be brazed with a brazing filler metal in accordance with AWS A5.8. Brazing filler metal shall be applied at the point where the pipe or tubing enters the socket of the fitting.

**316.2.2 Mechanical Joints.** Mechanical joints shall include, but are limited to, compression, flanged, grooved, pressed, and push fit fittings.

**316.2.2.1 Mechanically Formed Tee Fittings.** 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 of $\frac{1}{4}$ 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.

**316.2.2.2 Pressed-Connect Joints.** Pressed fittings for copper 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. Pressed fittings for copper 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 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.

**316.2.2.3 Push-Connect Joints.** Removable and nonremovable push fit fittings for copper pipe or tubing that employ quick assembly push fit connectors shall be in accordance with ASSE 1061. Push fit fittings for copper 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.
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.

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.

316.2.3 Soldered joints. Solder joints between copper pipe or tubing and fittings shall be made in accordance with the methods of ASTM B828 with the following sequence of joint preparation and operation as follows: measuring and cutting, reaming, cleaning, fluxing, assembly and support, heating, applying the solder, cooling and cleaning. Pipe or tube shall be cut square and reamed to the full inside diameter including the removal of burrs on the outside of the pipe and tubing. Surfaces to be joined shall be cleaned bright by manual or mechanical means. Flux shall be applied to pipe or tubing and fittings 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. Heat shall be applied using an air or fuel torch with the flame perpendicular to the pipe or tubing using acetylene or an LP gas. Preheating shall depend on the size of the joint. The flame shall be moved to the fitting cup and alternate between the pipe or tubing and fitting. Solder in accordance with ASTM B32 and 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.

Substantiation:

1. The plumbing connections requirements in Section 315.1 (Pipe, Tube, and Fittings) through Section 312.3 (Hard-Drawn Copper Alloy Tubing) are outside the scope of the UMC as water supply, sanitary drainage, and backflow prevention are within the purview of the UPC. Furthermore, the requirements added to the UMC (Section 515.2 and Section 315.3) use language obtained directly from Section 604.2 (Copper or Copper Alloy Pipe) and Section 604.3 (Hard-Drawn Copper or Copper Alloy Tubing) of the UPC which are only applicable for water supply and distribution.

2. The language in Section 316.0 through Section 316.2.3 of the UMC do not correlate with the language found in the UPC (Section 601.1 through 605.1.5) for copper or copper alloy pipe, tubing, and joints.

3. The material requirements added in Chapter 3 creates inconsistencies and conflicts throughout the code. The language is in conflict with ASHRAE 15, ASME B31.5, and Chapter 13 (Section 1308.5.10.1) which is an NFPA 54 extraction. Other examples of conflicts are as follows:
   a. For example, Section 316.2.3 will permit the use of solder throughout the code, and Section 1308.5.10.1 only permits brazing to be used for fuel gas piping. Furthermore, Chapter 11 only permits soldering to be used only for refrigeration systems with Group A1 refrigerants.
   b. ASHRAE 15 only allows Type K and Type L to be used for unprotected piping, and Section 312.3 will permit Type M to be used which is now in conflict with ASHRAE 15.
   c. Chapter 11 (Section 1109.1.1 and Section 1109.1.2) indicates that refrigerant piping shall be in accordance with ASHRAE 15.
with ASME B31.1. However, ASME B31.1 contains joining methods that are not permitted for all refrigerant-type systems which will be in conflict with the added provisions in Item # 316. The type of joining method is dependent on the type of refrigerant system being used and are not applicable to all types of refrigeration systems.

d. The provisions in Chapter 3 are repetitive to the joints and connections provisions that already addressed in Chapter 12 which will create confusion in the field in regards to enforcement and application.

TCC ITEM 18

2015 UNIFORM PLUMBING CODE

ITEM # 266

2015 UNIFORM MECHANICAL CODE

ITEMS # 052, # 053, # 054,

# 056, # 057, # 058

RECOMMENDATION:

814.0 Condensate Waste and Control.

814.1 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 \( \frac{1}{4} \) 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 814.3 or Section 814.4 for air-cooling coils or condensing appliances, respectively. Condensate or wastewater shall not drain over a public way.

814.2 Condensate Control. Where a cooling coil or cooling unit, an equipment or appliance is located installed in an attic or furred-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 814.1. 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 metal material, with a separate drain line, shall be installed beneath the cooling coil, unit, or the appliance top to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow, and a separate secondary drain shall be permitted to be provided in lieu of the secondary drain pan.

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 standing overflow additional drain

310.0 Condensate Waste and Control.

310.1 Condensate Disposal. Condensate from air washers, air-cooling coils, fuel-burning 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 \( \frac{1}{4} \) 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 either Section 310.3 or Section 310.4 for air-cooling coils or condensing fuel-burning appliances, respectively. Condensate or wastewater shall not drain over a public way.

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 pri-
814.3 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 814.3. 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 814.3

<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>(\frac{3}{4})</td>
</tr>
<tr>
<td>21 – 40</td>
<td>1</td>
</tr>
<tr>
<td>41 – 90</td>
<td>1(\frac{1}{4})</td>
</tr>
<tr>
<td>91 – 125</td>
<td>1(\frac{1}{2})</td>
</tr>
<tr>
<td>126 – 250</td>
<td>2</td>
</tr>
</tbody>
</table>

For SI units: 1 ton of refrigerant = 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 \(\frac{1}{8}\) inch per foot (10.4 mm/m) or 1 percent slope, with the pipe running three-quarters full at the following pipe conditions:

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 \(\frac{1}{8}\) inch per foot (10.4 mm/m) or 1 percent slope, with the pipe running three-quarters full at the following pipe conditions:
Condensate drain sizing for other slopes or other conditions shall be approved by the Authority Having Jurisdiction.

Air-conditioning waste pipes shall be constructed of materials specified in Chapter 7.

**814.3.1 Cleanouts.** Condensate drain lines shall be configured or provided with a cleanout to permit the clearing of blockages and for maintenance without requiring the drain line to be cut.

**814.4 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.

**814.5 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 properly 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.

**814.6 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.

**814.7 Plastic Fittings.** Female plastic screwed fittings shall be used with plastic male fittings and plastic threads.

<table>
<thead>
<tr>
<th>ITEM # 266</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Air – 20%</td>
<td>Room Air – 80%</td>
</tr>
<tr>
<td>DB</td>
<td>WB</td>
</tr>
<tr>
<td>90°F</td>
<td>73°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.

**310.3.1 Cleanouts.** Condensate drain lines shall be configured or provided with a cleanout to permit the clearing of blockages and for maintenance without requiring the drain line to be cut.

**310.4 Fuel-Burning-Appliance Condensate Drains.** Condensate drain lines from individual fuel-burning 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 properly 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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Accept recommendation as submitted.</td>
<td>Reject the recommendation.</td>
</tr>
</tbody>
</table>

**Substantiation:**

1. The revisions made to Section 814.2 (Condensate Control) of the UPC will correlate with the actions taken by the UMC TC to “accept the public comment as submitted” Item # 053 and to “accept as submitted” Item # 054.

**The substantiation provided by the UMC Item # 053 is as follows:**

1. The revisions to Section 312.2 will require an additional drain pipe, additional drain pan, or a level detecting device to protect the structure from condensate waste. The code currently does not provide the option for the installation of a water detecting device which is widely used in the industry for condensate protection.
2. Last sentence of Section 312.2 should be deleted as the provisions in Section 312.2 through Section 312.4 should all be adhered to in order to comply with the UMC.
3. This modification to the proposal adds more detail in option 2, and adds a 4th option for controlling condensate. Item # 002 requires a drain pan for collecting condensate, but stops short of requiring the condensate to be able to
drain from the pan, which could easily overflow and cause water damage if the equipment continues running. The new 4th option permits the use of a pan with a water detection device that would shut the equipment off, rather than draining of the pan. It is a nonmandatory option, and shut off may be the more appropriate and practical solution for some types of appliances."

The substantiation provided by the UMC Item # 054 is as follows: “This section is intended to protect drywall, wood structural elements, etc. not to protect something inexpensive like a ceiling tile. The overflow is often just poked through the ceiling so that now damage occurs to the carpet or flooring rather than an inexpensive ceiling tile. The stain on the tile is a better indicator of a leak than a stain on the floor.”

2. The revisions made to Section 814.3 (Condensate Waste Pipe Material and Sizing) of the UPC will correlate with the actions taken by the UMC TC to “accept as submitted” Item # 057.

The substantiation provided by the UMC Item # 057 is as follows: “The revisions to Section 312.3 will guide the end user in selecting the correct material for condensate waste piping since the code is silent on such material requirements. Furthermore, in Section 312.7, the text "PVC" is being replaced with "plastic" since there are other plastic screwed fittings that can be used for condensate drains, as long as they meet the pressure and temperature ratings of the appliance or equipment.”

3. The revisions made to Section 814.5 (Point of discharge) of the UPC will correlate with the actions taken by the UMC TC to “accept as submitted” Item # 058.

The substantiation provided by the UMC Item # 058 is as follows: “The revisions to Section 312.6 will require condensate traps to comply with the manufacturer’s instructions. A properly functioning and designed condensate trap provides for discharge of water from the cooling coil drain pan, while the water seal (the water level maintained in the trap) prevents the flow of ambient air into or out of the air handler. Several problems result from improperly trapped systems, some of which can severely impact indoor air quality. Where a trap is improperly installed or designed, an incoming air stream may be introduced through the drain and the air flowing through the coil can possibly spray condensate into the fan intake, which can propel the moisture into other parts of the system; which can then be carried through the ducts and into the conditioned space possibly causing bacterial growth and transmission. Furthermore, improperly trapped systems can include the trap outlet is too short or the trap outlet is too tall, or other potential incorrect sizing. The manufacturer of the appliance typically provides trapping requirements that should be followed when sizing the condensate drainage trap.”

4. New Section 814.2.1 (Condensate Pumps) added to the UPC will correlate with the action taken by the UMC TC to “accept the public comment as submitted” Item # 052.

The substantiation provided by the UMC Item # 052 is as follows: “Inspectors encounter multiple situations where condensate pumps are installed where they are not needed. In the cases where they are needed, they are not addressed by the code and are installed with 3/8 inch unlisted clear tubing to the exterior of the building; ignoring other sections which prohibit disposal over the public right of way. We have encountered over 100 ft of tubing run horizontally to the exterior or to open drains. Pumps sold as condensate are made to lift water, not to “throw” it multiple feet. This proposal gives the Authority Having Jurisdiction the authority to cite a specific code section which is currently lacking in the UMC.”

5. New Section 814.2.2 (Protection of Appurtenances) added to the UPC will correlate with the action taken by the UMC to “accept as submitted” Item # 056.

The substantiation provided by the UMC Item # 056 is as follows: “Section 312.2.1 is necessary to clarify to the end user that insulation and appurtenances such as piping or devices should be installed at a height that will prevent the condensate waste from having direct contact due to overflow of the drain pan. Furthermore, the supports used to achieve the necessary height should be of a material that is corrosion-resistant.”
6. New Section 814.3.1 (Cleanouts) added to the UPC will correlate with action taken by the UMC to “accept as submitted” Item # 057 (Public Comment 2).

The substantiation provided by the UMC Item # 057 (Public Comment 2) is as follows: “Typically, when a condensate drain line is clogged, the technician cuts the drain line, and then collects as much of the waste water as possible. The technician then clears out the drain line and repairs it with a collar and PVC glue. It is possible with a drain cleanout device or by plumbing the drain line properly to avoid the necessity of cutting the drain line and repairing it. This saves time, money, and the problem of the waste water contaminating the residence. The proposed language was recently adopted into the 2015 IMC and 2015 IRC.”

7. New Section 814.7 (Plastic Fittings) added to the UPC will correlate with the action taken by the UMC TC to “accept as submitted” Item # 057.

The substantiation provided by the UMC Item # 057 is as follows: “The revisions to Section 312.3 will guide the end user in selecting the correct material for condensate waste piping since the code is silent on such material requirements. Furthermore, in Section 312.7, the text “PVC” is being replaced with “plastic” since there are other plastic screwed fittings that can be used for condensate drains, as long as they meet the pressure and temperature ratings of the appliance or equipment.”

8. The revisions made to the UMC in Section 310.1 (Condensate Disposal) and Section 310.4 (Fuel-Burning Appliance Condensate appliance Condensate Drains) will correlate with actions taken by the UPC TC to “accept public comment as submitted” Item # 266 (Public Comment 2).

The substantiation provided by the UPC Item # 266 (Public Comment 2) is as follows: “These requirements are applicable to all condensing appliances and should not be restricted to only those that are fuel-burning. Text has been modified to eliminate reference to fuel-burning appliances to clarify that the requirements apply to all types of condensing appliances.”
1208.5.4 Plastic Pipe, Tubing, and Fittings. Polyethylene plastic pipe, tubing, and fittings used to supply fuel gas shall be in accordance with ASTM D2513. Pipe to be used shall be marked "gas" and "ASTM D2513." [NFPA 54-12:5.6.4.1.1]

1308.5.4 Plastic Pipe, Tubing, and Fittings. Polyethylene plastic pipe, tubing, and fittings used to supply fuel gas shall be in accordance with ASTM D2513. Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009. Pipe to be used shall be marked “gas” and “ASTM D2513.” [NFPA 54-12:5.6.4.1.1, 5.6.4.1.2]

### TABLE 1701.1

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
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<tr>
<td>ASTM D2513-2009</td>
<td>Thermoplastic Gas Pressure Pipe, Tubing, and Fittings</td>
<td>Fuel Gas</td>
<td>1308.5.4</td>
</tr>
</tbody>
</table>

(Portions of table not shown remain unchanged)

**Substantiation:**

The revision to Section 1308.5.4 of the UMC will correlate with Section 1208.5.4 in regards to plastic pipe, tubing, and fittings. The language "Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009" was added to Section 1308.5.4 of the UMC in Item # 335. However, the language does not correlate with the UPC. Therefore, it should be removed to correlate with similar Section 1208.5.4 of the UPC.

A public comment was submitted to the UMC to remove the language “Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009.” However, the public comment was rejected by the UMC TC. The Committee statement provided by the UMC TC for rejecting the public comment Item # 335 is as follows: “The scope of the 2009 edition of ASTM D2513 was modified to include only polyethylene piping. Polyamide piping has been used successfully as fuel gas piping for many years. Polyamide piping should conform to the 2009 edition of ASTM D2513 until such time that ASTM publishes a new standard on polyamide piping for fuel gas applications.”

**Note:** The TCC had previously voted (TCC ITEM 16) to not accept the language proposed Item # 335 of the UMC; the TCC voted to keep the language shown for the UPC. However, the UMC TC voted to reject the public comment submitted to remove the text “Plastic pipe, tubing and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009” from the UMC. **The reason provided by the TCC (TCC ITEM 16) for rejecting the recommendation to correlate is as follows:** “The TCC feels that polyamide is not a common material, and therefore should be accepted as an alternative material based on Section 301.2”

| | Accept recommendation as submitted. | Reject the recommendation. |
TCC ITEM 20

RECOMMENDATION:

**1208.5.8.1 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.

**1308.5.10.1 Pipe Joints.** Pipe joints shall be threaded, flanged, brazed, welded, or made by 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.

<table>
<thead>
<tr>
<th>x</th>
<th>Accept recommendation as submitted.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject the recommendation.</td>
</tr>
</tbody>
</table>

**Substantiation:**
The revision to Section 1308.5.10.1 of the UMC will correlate with the actions taken by the UPC TC to "accept the public comment as amended" Item # 301.

**The Committee statement provided by the UPC TC for accepting Item # 301 as amended is as follows:** "The proposed modification will clarify the intent of the section in regards to press-connect fittings for pipe joints."

TCC ITEM 21

**RECOMMENDATION:**

**E 23.2 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]

**D 1.2 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 in a work-like manner. For the installation of liquefied petroleum gas (LPG) storage systems, the applicable provisions of NFPA 58 shall be followed. [NFPA 501A:4.1.2].

**E 24.1.2 Requirements.** The open-ended gastight conduit shall comply with the following:

(1) – (3) (remaining text unchanged)

(4) Where the conduit terminates within a M/H, 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]

**D 2.1.2 Requirements.** The open-ended gastight conduit shall comply with the following:

(1) – (3) (remaining text unchanged)

(4) Where the conduit terminates within a M/H, accessory building, or structure, it shall be readily 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]

**E 25.1 General.** Each M/H site shall have a listed gas shutoff valve installed upstream of the M/H site gas outlet. The gas shutoff valve shall be readily 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]

**D 3.1 General.** Each M/H site shall have a listed gas shutoff valve installed upstream of the M/H site gas outlet.
E 27.0 Cathodic Protection Requirements.
E 27.1 General. (remaining text unchanged)

E 28.0 Manufactured Home Community LPG Supply Systems.
E 28.1 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 supply systems and the storage and handling of LPG shall be in accordance with NFPA 58 (see Section E 33.0). [NFPA 501A:4.3.2]

E 29.0 Required Gas Supply.
E 29.1 General. (remaining text unchanged)

TABLE E 29.1
DEMAND FACTORS FOR USE IN CALCULATING GAS PIPING SYSTEMS IN M/H COMMUNITIES*
[NFPA 501A: TABLE 4.3.4.1, 4.3.4.2]

(portions of table not shown remain unchanged)

E 30.0 Gas Pipe Sizing and Pressure.
E 30.1 Size. (remaining text unchanged)
E 30.2 Pressure. (remaining text unchanged)
E 31.0 Gas Piping Materials.
E 31.1 Metal. (remaining text unchanged)
E 31.2 Protection Coatings for Metal Gas Piping. (remaining text unchanged)
E 31.3 Plastic. (remaining text unchanged)

E 32.0 Gas Piping Installations.
E 32.1 Minimum Burial Below Ground Level and Clearances. (remaining text unchanged)
E 32.2 Metallic Gas Piping. (remaining text unchanged)
E 32.2.1 Cathodic Protection. (remaining text unchanged)
E 32.2.2 Underground Metallic Systems. (remaining text unchanged)
E 32.3 Plastic Gas Piping. (remaining text unchanged)
E 32.4 Gas Piping System Shutoff Valve. An accessible and identifiable shutoff valve controlling the flow of gas to the entire M/H community gas piping system shall be installed in a location approved by the Authority Having Jurisdiction and near the point of connection to the service piping or to the supply connection of an LPG container. [NFPA 501A:4.3.7.4]

E 33.0 Liquefied Petroleum Gas Equipment.
E 33.1 General. (remaining text unchanged)

E 34.0 Oil Supply.
E 34.1 General. (remaining text unchanged)
E 34.2 Minimum Oil Supply Tank Size. (remaining text unchanged)
E 34.3 Oil Supply Connections. Oil supply connections at M/H sites, where provided from a centralized oil distribution system, shall be located and arranged to permit attachment to a M/H utilizing the stand. [NFPA 501A:4.3.11.1]

E 35.0 Fuel Supply Systems Installation.
E 35.1 Flexible Gas Connector. Each gas supply connector shall be listed for outside M/H use, shall be not more than 6 feet (1829 mm) in length, and shall have a capacity rating to supply the connected load.
3.5.3 1

han 14 inches water co
cally
l-

sfactory completion of the fuel gas piping
o
n-

h-

p

E 35.6.4 Vent. Tanks with a capacity not larger than 660 gallons (2498 L) shall be equipped with an open vent not smaller than 1½ inch (40 mm) iron pipe size; tanks with a 500 gallon (1892 L) or less capacity shall have a vent of 1¼ inch (32 mm) iron pipe size.

E 35.3 Mechanical Protection. (remaining text unchanged)

E 35.4 Special Rules on Atmospherically Controlled Regulators. (remaining text unchanged)

E 35.5 Fuel Gas Piping Test. (remaining text unchanged)

E 35.5.1 Procedures. The fuel gas piping test shall consist of air pressure of 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 ⅛ of an inch (2.5 mm) or ⅛ psi (0.7 kPa gauge), as applicable. Upon satisfactory completion of the fuel gas piping test, the M/H gas supply connector shall be installed, and the connections shall be tested with soapy water or bubble solution. [NFPA 501A:4.4.5.1]

E 35.5.2 Warning. (remaining text unchanged)

E 35.5.3 Vents. (remaining text unchanged)

E 35.6 Oil Tanks. Not more than one 660 gallon (2498 L) tank or two tanks with aggregate capacity of 660 gallons (2498 L) or less shall be connected to one oil-burning appliance. Two supply tanks, where used, shall be cross-connected and provided with a single fill and single vent in accordance with NFPA 31, and shall be on a common slab and rigidly secured one to the other. 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]

E 35.6.1 Installation. (remaining text unchanged)

E 35.6.2 Capacity. (remaining text unchanged)

E 35.6.3 Location. (remaining text unchanged)

E 35.6.4 Vent. Tanks with a capacity not larger than 660 gallons (2498 L) shall be equipped with an open vent not smaller than 1½ inch (40 mm) iron pipe size; tanks with a 500 gallon (1892 L) or less capacity shall have a vent of 1¼ inch (32 mm) iron pipe size.
E 35.6.5 Liquid Level. (remaining text unchanged)

E 35.6.6 Fill Opening. (remaining text unchanged)

E 36.0 Manufactured Home Accessory Building Fuel Supply Systems.

E 36.1 General. (remaining text unchanged)

E 37.0 Community Building Fuel Supply Systems in Manufactured Home Communities.

E 37.1 Fuel Gas Piping and Equipment Installations. Fuel gas piping and equipment installed within a permanent building in a M/H 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:4.4.6.1]

E 37.2 Oil Supply Systems in M/H Communities. Oil burning equipment and installation within a M/H 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]

E 37.3 Oil-Burning Equipment and Installation. Oil burning equipment and installation within a building constructed in a M/H 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]

E 37.4 Inspections and Tests. (remaining text unchanged)
<table>
<thead>
<tr>
<th>ITEM # 359</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ITEM # 145 (Public Comment 1)</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 16.4 D 15.4 Inspections and Tests.</td>
<td>(remaining text unchanged)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>x</th>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
</tr>
</thead>
</table>

**Substantiation:**
The revisions to Appendix D of the UMC will correlate with the actions taken by the UPC TC to "accept the public comment as submitted" Item # 359 in regards to updating the manufactured home provisions in accordance with NFPA 501A.

The substantiation provided by the UPC for accepting the public comment Item # 359 as submitted is as follows:

1. "Sections within Appendix E of the UPC are being revised to correlate with NFPA 501A-2013 (latest version) in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines)."
2. "Section E 27.0 (Multiple Manufactured Home Site Fuel Distribution and Supply Systems) should be deleted as it does not contain any provisions that can be applied or enforced."
### APPENDIX M (UPC)

**RECOMMENDED PLASTIC PIPING FOR SPECIFIC GREEN APPLICATIONS**

#### M.101.0 General

**M.101.1 Applicability.** Table M.101.1 is intended to give guidance on plastic piping in accordance with manufacturing standards for applications encouraged or required by green and sustainable codes, standards, rating systems, or other documents outside of the base plumbing or mechanical codes.

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>ABS</th>
<th>CR/VC</th>
<th>PE</th>
<th>PE-AL-PE</th>
<th>PE-R</th>
<th>PEX</th>
<th>PEX-AL-PE</th>
<th>PP</th>
<th>PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Vacuum System piping</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>ASTM F2158</td>
<td></td>
</tr>
<tr>
<td>Foundation Drainage System piping</td>
<td>ASTM F628</td>
<td>–</td>
<td>–</td>
<td>ASTM F405</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>ASTM F2665, ASTM F2729, ASTM D3034</td>
<td></td>
</tr>
<tr>
<td>Loop piping</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>ASTM F2389, CSA B137.11</td>
<td></td>
</tr>
</tbody>
</table>
### Pressure/distribution – ASTM D2846, ASTM E441, ASTM E442, ASTM F2885, CSA-B137.6

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radon Venting System Piping</td>
<td>ASTMD E628</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Residential Fire Sprinklers</td>
<td>Sprinkler Piping</td>
<td>ASTM E441, ASTM E442, CSA-B137.6, UL 1821</td>
<td>-</td>
<td>-</td>
<td>ASTM F2769</td>
<td>ASTM F876, CSA B137.5, UL 1821</td>
<td>-</td>
</tr>
<tr>
<td>Solar Heating Pressure/distribution</td>
<td>ASTM D2846, ASTM E441, ASTM E442, ASTM F2885</td>
<td>-</td>
<td>-</td>
<td>ASTM F2623, ASTM F2769</td>
<td>ASTM F876, CSA B137.5</td>
<td>ASTM F2389, CSA B137.11</td>
<td>-</td>
</tr>
</tbody>
</table>

**Notes:**
1. This table is intended to describe plastic piping materials in accordance with manufacturing standards that are approved for use in the green and sustainable applications listed. The user shall verify such application with the local codes and the manufacturer.
2. Use fittings approved for the piping being used or as recommended by the manufacturers of the piping and fittings.
3. Fire sprinkler applications shall use piping systems listed for the application.

### Accept recommendation as submitted. | x | Reject the recommendation.

**Note:** TCC Item # 022 failed to achieve the necessary 3/4 affirmative vote of returned ballots. In accordance with Section 4-4.7.2 of the Regulations Governing Committee Projects, Appendix M is being returned to the TC.

**Substantiation:**

The TCC believes that Appendix M should not be deleted as it is not a correlation item. Furthermore, Item # 369 was accepted by the UPC TC. Lastly, even though the UMC rejected a similar proposal during the ROP stage, Section 101.4 of the UPC states that the UPC shall prevail over the UMC.

The deletion of Appendix M (Recommended Plastic Piping For Specific Green Applications) of the UPC will correlate with the actions taken by the UMC TC to “reject” Item # 369.

**The Committee statement provided by the UMC TC for “rejecting” Item # 369 is as follows:** "The proposed text was rejected based on the concern that not all applicable standards related to the application are listed in the table."

Furthermore, the language proposed in Item # 369 of the UPC is violation of Section 1.2 (Code References) of IAPMO’s Guidelines for Referencing Mandatory Standards which was adopted by the IAPMO Standards Council on August 21, 2013 as it does not tell the end user how to apply the standards. It is only a table with a collection of standards without any guidance for the end user on how the standards shall be applied. Therefore, it is in violation of Section 1.2 (Code References) of IAPMO’s Guidelines for Referencing Mandatory Standards which was adopted
by the IAPMO Standards Council on August 21, 2013.

For informational purposes only, Section 1.2 is shown as follows: "Mandatory standards shall be identifiable by title, date or edition, and name of the developing organization. The manner in which it is to be utilized shall be specifically referenced in the Code text (referenced section that applies), all in accordance with the IAPMO Manual of Style."
PART III – CORRELATION ITEMS BETWEEN THE 2015 UMC and USEHC

TCC ITEM 23

<table>
<thead>
<tr>
<th>ITEM # 230, ITEM 313 (Public Comment 2)</th>
<th>2015 UNIFORM MECHANICAL CODE</th>
</tr>
</thead>
</table>

RECOMMENDATION:

1005.0 Expansion Tanks.
1005.1 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.

1005.3 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.

1005.4 Minimum Capacity of Closed-Type Tank. The minimum capacity for a gravity-type hot water expansion tank shall be in accordance with Table 1005.4(1). The minimum capacity for a forced-type hot water expansion tank shall be in accordance with Table 1005.4(2) or Equation 1005.4. Equation 1005.4 shall not be used for diaphragm-type expansion tanks.

(Equation 1005.4)

\[ V_t = \frac{(0.00041f - 0.0466) V_s}{\left(\frac{P_f - P_o}{P_0}\right)} \]

605.1 Expansion Tanks.
605.1 Where Required. An expansion tank shall be installed in a solar-thermal hot-water heating system where a pressure reducing valve, backflow prevention device, check valve or other device is installed on a water supply system utilizing storage or tankless water heating equipment 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 strain on the connecting piping.

Solar-thermal Hot-water-heating systems incorporating hot water tanks or fluid relief columns shall be installed to prevent freezing under normal operating conditions.

605.3 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 or above more than 30 pounds-force per square inch (psi) (207 kPa) shall comply with ASME BPVC Section VIII be constructed in accordance with nationally recognized standards and the Authority Having Jurisdiction. Provisions shall be made for draining the tank without emptying the system, except for pressurized tanks.

605.4 Minimum Capacity of Closed-Type Tank. The minimum capacity of a closed-type for a gravity-type hot water system expansion tank shall be in accordance with Table 605.4(1). The minimum capacity for a forced-type hot water system expansion tank shall be in accordance and Table 605.4(2) or Equation 605.4 from the following formula:

(Equation 605.4)

\[ V_t = \frac{(0.00041f - 0.0466) V_s}{\left(\frac{P_f - P_o}{P_0}\right)} \]
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 H\(_2\)O absolute.
\(P_f\) = Fill pressure, feet H\(_2\)O absolute.
\(P_o\) = Maximum operating pressure, feet H\(_2\)O absolute.

### TABLE 1005.4(1)
EXPANSION TANK CAPACITIES FOR GRAVITY HOT WATER SYSTEMS

<table>
<thead>
<tr>
<th>INSTALLED EQUIVALENT DIRECT RADIATION(^2) (square feet)</th>
<th>TANK CAPACITY (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 350</td>
<td>18</td>
</tr>
<tr>
<td>Up to 450</td>
<td>21</td>
</tr>
<tr>
<td>Up to 650</td>
<td>24</td>
</tr>
<tr>
<td>Up to 900</td>
<td>30</td>
</tr>
<tr>
<td>Up to 1100</td>
<td>35</td>
</tr>
<tr>
<td>Up to 1400</td>
<td>40</td>
</tr>
<tr>
<td>Up to 1600</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 1800</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 2000</td>
<td>2 to 35</td>
</tr>
<tr>
<td>Up to 2400</td>
<td>2 to 40</td>
</tr>
</tbody>
</table>

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 \([\text{Btu/(ft}^2\cdot\text{h})]\) (473 W/m\(^2\)) equivalent direct radiation.
2. For systems exceeding 2400 square feet (222.9 m\(^2\)) 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 m\(^2\)) of additional equivalent direct radiation.

For SI units: 1 gallon = 3.785 L, 1 square foot = 0.0929 m\(^2\)

### TABLE 605.4(1)
EXPANSION TANK CAPACITIES FOR GRAVITY HOT WATER SYSTEMS

<table>
<thead>
<tr>
<th>INSTALLED EQUIVALENT DIRECT RADIATION(^2) (square feet)</th>
<th>TANK CAPACITY (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 350</td>
<td>18</td>
</tr>
<tr>
<td>Up to 450</td>
<td>21</td>
</tr>
<tr>
<td>Up to 650</td>
<td>24</td>
</tr>
<tr>
<td>Up to 900</td>
<td>30</td>
</tr>
<tr>
<td>Up to 1100</td>
<td>35</td>
</tr>
<tr>
<td>Up to 1400</td>
<td>40</td>
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<tr>
<td>Up to 1600</td>
<td>2 to 30</td>
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<tr>
<td>Up to 1800</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 2000</td>
<td>2 to 35</td>
</tr>
<tr>
<td>Up to 2400</td>
<td>2 to 40</td>
</tr>
</tbody>
</table>

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 \([\text{Btu/(ft}^2\cdot\text{h})]\) (473 W/m\(^2\)) equivalent direct radiation.
2. For systems exceeding 2400 square feet (222.9 m\(^2\)) of installed equivalent direct water radiation, the required capacity of the cushion tank shall be increased on the basis of 1 gallon (3.785 L) tank capacity per 33 square feet (3.1 m\(^2\)) of additional equivalent direct radiation.
TABLE 1005.4(2)
EXPANSION TANK CAPACITIES FOR FORCED HOT WATER SYSTEMS1

<table>
<thead>
<tr>
<th>SYSTEM VOLUME2 (gallons)</th>
<th>TANK CAPACITY DIAPHRAGM TYPE (gallons)</th>
<th>TANK CAPACITY NONDIAPHRAGM TYPE (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>200</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>300</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>400</td>
<td>33</td>
<td>60</td>
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<td>500</td>
<td>42</td>
<td>75</td>
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<tr>
<td>1000</td>
<td>83</td>
<td>150</td>
</tr>
<tr>
<td>2000</td>
<td>165</td>
<td>300</td>
</tr>
</tbody>
</table>

For SI units: 1 gallon = 3.785 L.

Notes:
1 Based on an average operating water temperature of 195°F (91°C), a fill pressure of 12 psig (83 kPa), and an operating pressure of not more than 30 psig (207 kPa).
2 Includes volume of water in boiler, radiation, and piping, not including expansion tank.

Accept recommendation as submitted. x Reject the recommendation.

Substantiation:

The TCC believes that the USEHC TC should decide to whether correlate with the UMC as it addresses unique requirements that are not applicable to both codes. The USEHC TC should decide the expansion tank sizing requirements for solar energy systems.

The revisions to Sections 605.1, 605.3, Section 605.4, Table 605.4(1), and Table 605.4(2) of the USEHC will correlate with the actions taken by the UMC TC to “accept the public comment as submitted” Item # 230. Furthermore, the text “except for pressurized tanks” is being removed from Section 605.3 of the USEHC is being deleted to correlate with the action taken by the UMC TC to “accept the public comment as submitted” Item # 313 (Public Comment 2).

The substantiation provided by the UMC for accepting Item # 230 as submitted is as follows:

1. Section 1005.3 should be modified as ASME BPVC Section VIII is the nationally recognized standard for expansion tanks exceeding 30 psi. Furthermore, the text “pressurized” should be modified to “nondiaphragm-type” to be consistent with the modification made to Table 1005.4(2) and with language used in Section 1209.2. It should be noted that ASME BPVC Section IV uses the term “prepressurized” when referring to a diaphragm-type tank and “nonpressurized” when referring to a nondiaphragm-type tanks. However, the terminologies used throughout the UMC are “diaphragm-type” and “nondiaphragm-type,” and therefore the terminology used in ASME was not used to avoid any confusion.

2. Section 1005.4 is being modified for clarity. Furthermore, the text “Equation 1005.4 shall not be used for diaphragm-type expansion tanks” is being added to clarify to the end user that Equation 1005.4 only applies to nondiaphragm expansion tanks. Diaphragm-type expansion tanks are pre-engineered which are sized in accordance with the manufacturers of the expansion tank or boiler.

3. Table 1005.4(2) should be modified to correlate with the expansion tank capacity table found in ASME BPVC Section IV. The UMC addresses requirements for diaphragm type tanks, and therefore tank capacities are required in the code. Furthermore, such modification is necessary so that it can be applicable with Section 1209.2.
The substantiation provided by the UMC for accepting Item # 313 (Public Comment 2) as submitted is as follows:

“All expansion tanks, bladder type, diaphragm type, and open steel tank type require a drain valve between the isolation valve and the tank. This is to facilitate required annual testing and recharging of the tank’s diaphragm or bladder pressure. The manufacturers state in their installation literature that in order to correctly check the diaphragm/bladder pressure that the fluid side must be bled to a pressure of zero psi gauge. Without this convenient drain, it becomes necessary to release the pressure from another part of the physical plant, thereby causing air binding and other issues. In the case of an open steel (bladder-less and diaphragm-less) tank, it is there to facilitate the complete draining and atmospheric pressure balancing of the tank prior to recharging with the system fluid.”

**TCC ITEM 24**

**RECOMMENDATION:**

210.0

**Hydronics.** Of or relating to a heating or cooling system that transfers energy by circulating a fluid through a system of pipes or tubing.

<table>
<thead>
<tr>
<th></th>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Substantiation:**

The new definition for “hydronics” added to the USEHC will correlate with actions taken by the UMC TC to “accept the public comment as submitted” Item # 305.

The substantiation provided by the UMC for accepting Item # 305 as submitted is as follows:

“The term “hydronics” is referenced throughout Chapter 12 without being defined. The proposed definition assists the end user in applying and enforcing this term.”
TCC ITEM 25

**RECOMMENDATION:**

**1203.2 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. 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 1203.2 WATER HEATERS**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas, 75 000 Btu/h or less</td>
<td>CSA Z21.10.1</td>
</tr>
<tr>
<td>Gas, Above 75 000 Btu/h</td>
<td>CSA Z21.10.3</td>
</tr>
<tr>
<td>Electric, Space Heating</td>
<td>UL 834</td>
</tr>
<tr>
<td>Solid Fuel</td>
<td>UL 2523</td>
</tr>
</tbody>
</table>

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

**1207.2 Boilers.** Boilers and their control systems shall comply with Section 1002.0.

**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. 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 403.2 WATER HEATERS**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas, 75,000 Btu/hr or less</td>
<td>CSA Z21.10.1</td>
</tr>
<tr>
<td>Gas, above 75,000 Btu/hr</td>
<td>CSA Z21.10.3</td>
</tr>
<tr>
<td>Electric, space heating</td>
<td>UL 834</td>
</tr>
<tr>
<td>Solid fuel, hydronic</td>
<td>UL 2523</td>
</tr>
</tbody>
</table>

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

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

**405.2 Boilers.** Boilers and their controls shall comply be designed and constructed in accordance with the mechanical code.

**405.3 Dual-Purpose Water Heaters.** Water heaters used for combined space- and water-heating applications shall be in accordance with CSA Z21.10.1 or CSA Z21.10.3- the standards referenced in Table 403.2, and shall be installed in accordance with the manufacturer’s installation instructions. The total heating capacity of a dual purpose water heater shall be based on the sum of the potable hot water requirements and the space heating design requirements corrected for hot water first hour draw recovery.

<table>
<thead>
<tr>
<th></th>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Substantiation:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The revisions to Section 403.2, Section 405.2, Section 405.3, and Table 403.2 of the USEHC will correlate with actions taken by the UMC TC to “accept the public comment as amended” Item # 307.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The substantiation provided by the UMC for accepting Item # 307 as amended is as follows:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Section 1207.2, the text was modified to refer to the existing requirements in Section 1002 for boiler requirements rather than repeating text in this section.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In Section 1203.2 and Section 1207.3, the text was modified, and Table 1203.2 was added, to clarify the listing requirements for water heaters that correlate with the UPC (Item # 155). Item # 155 of the UPC was accepted with</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
modifications, which eliminated UL 834 for electric space heating heaters because UL 834 was not within the scope of the UPC. However, UL 834 is within the scope of the UMC and should be included in this table. Furthermore, UL 732, UL 795, UL 1453, UL 834, and UL 2523 have already been proposed in Item # 197. Lastly, CSA Z21.10.1, CSA Z21.10.3, and UL 2523 are being relocated to Table 1203.2 from Section 1207.2 and Section 1207.3."

TCC ITEM 26

**RECOMMENDATION:**

1209.1 **Where Required.** An expansion tank shall be installed in every hydronic system to control thermal expansion. Secondary hot water systems, that are isolated from the primary system by a heat exchanger shall install a separate expansion tank and pressure relief valve. Expansion tanks shall be of the closed or open type. Expansion tanks used in hydronic systems shall comply with the requirements of ASME Boiler and Pressure Vessel Code Section VIII where the system is designed to operate at more than 30 pounds-force per square inch (psi) (207 kPa). Tanks shall be rated for the pressure of the system. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions.

1209.2 **Systems with Closed Expansion Tanks.** A closed expansion tank shall be sized based on the capacity of the system. The minimum size of the tank shall be determined in accordance with Section 1004.4 and shall be equipped with an airtight tank or other air cushion that is consistent with the volume and capacity of the system. Tanks shall be equipped with a drain valve and a manual air vent. Tanks shall be located in accordance with the manufacturer’s instructions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

406.1 **Where Required.** An expansion tank shall be installed in a hydronic system to control thermal expansion. Secondary hot water systems, that are isolated from the primary system by a heat exchanger shall install a separate expansion tank and pressure relief valve. Expansion tanks shall be of the closed or open type. Expansion tanks used in hydronic systems shall comply with the requirements of ASME Boiler and Pressure Vessel Code, Section VIII; where the system is designed to operate at more than 30 pounds-force per square inch (psi) (207 kPa); diameter of the tank exceeds 24 inches (610 mm) or where the operating temperature exceeds 250°F (121°C). Tanks shall be rated for the pressure of the system. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions.

406.2 **Systems with Closed Expansion Tanks.** A closed expansion tank shall be sized based on the capacity of the system. The minimum size of the tank shall be determined in accordance with Section 604.4 and shall be equipped with an airtight tank or other air cushion that is consistent with the volume and capacity of the system. Tanks without membranes shall be equipped with a drain valve and a manual air vent. Tanks shall be located in accordance with the manufacturer’s instructions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

| x | Accept recommendation as submitted. | Reject the recommendation. |

**Substantiation:**
The revisions to Section 406.1 and Section 406.2 of the USEHC will correlate with actions taken by the UMC TC to “accept the public comment as submitted” Item # 313 (Public Comment 1 and Public Comment 2).
The substantiation provided by the UMC for accepting Item # 313 (Public Comment 1) as submitted is as follows:

"Section 1209.1 should be modified as expansion tanks are required to comply with ASME BPVC Section VIII when the pressure is expected to exceed 30 psi. This is consistent with ASME BPVC Section IV and industry standards. Furthermore, it will be consistent with the requirements in Section 1004.3."

The substantiation provided by the UMC for accepting Item # 313 (Public Comment 2) as submitted is as follows:

"All expansion tanks, bladder type, diaphragm type, and open steel tank type require a drain valve between the isolation valve and the tank. This is to facilitate required annual testing and recharging of the tank’s diaphragm or bladder pressure. The manufacturers state in their installation literature that in order to correctly check the diaphragm/bladder pressure that the fluid side must be bled to a pressure of zero psi gauge. Without this convenient drain, it becomes necessary to release the pressure from another part of the physical plant, thereby causing air binding and other issues. In the case of an open steel (bladder-less and diaphragm-less) tank, it is there to facilitate the complete draining and atmospheric pressure balancing of the tank prior to recharging with the system fluid."

TCC ITEM 27

### RECOMMENDATION:

**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 in accordance with the manufacturer’s installation instructions. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

**1211.12 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 fitting.

**408.1 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 in accordance with the manufacturer’s installation instructions. Joints between pipe and fittings shall be installed in accordance with the manufacturer’s installation instructions.

**408.12 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 fitting.
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.

<table>
<thead>
<tr>
<th>Accept recommendation as submitted.</th>
<th>Reject the recommendation.</th>
</tr>
</thead>
</table>

**Substantiation:**
The revisions to Section 408.1 of the USEHC will correlate with the action taken by the UMC TC to “accept the public comment as amended” Item # 315 (Public Comment 2). Furthermore, the revision to Section 408.12 of the USEHC will correlate with the action taken by the UMC TC to “accept the public comment as submitted” Item # 315 (Public Comment 3).

The Committee statement provided by the UMC TC for accepting Item # 315 (Public Comment 2) as amended is as follows:

“Section 1211.1 was modified to provide clarity to the end user that the manufacturer’s installation instructions shall be used for the joining and connections using pipe bends.”

The substantiation provided by the UMC for accepting Item # 315 (Public Comment 3) as submitted is as follows:

“Section 1211.12 was revised as the section did not include description for press-connected joints for steel pipe and tube. This modification harmonizes the updated press connection fitting standard (IAPMO PS 117) that now includes materials other than copper. Furthermore, the language proposed is in harmony with Section 1211.3 (4).”

**TCC ITEM 28**

**RECOMMENDATION:**

1213.6 Simultaneous Operation. Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling.

1213.7 Temperature Reading. A temperature gauge or transmitter shall be installed for reading the following fluid temperatures:

1. The panel system supply and outlet. One temperature gauge or transmitter shall be permitted where the temperature between the heat source outlet and panel system supply are the same.

409.6 Simultaneous Operation. Radiant heating and cooling systems sharing a common space temperature control shall be configured to prevent simultaneous heating and cooling.

409.7 Temperature Reading. A temperature gauge or transmitter shall be installed for reading the following fluid temperatures:

1. The panel system supply and outlet. One temperature gauge or transmitter shall be permitted where the temperature between the heat source outlet and panel system supply are the same.
ITEM # 318  COMMENTS

(2) The heat source outlet and return line. One temperature gauge or transmitter shall be permitted where the temperature between the panel system outlet and the heat source return are the same.

Accept recommendation as submitted. X Reject the recommendation.

Substantiation:

The TCC believes that Section 1213.6 and Section 1213.7 are not applicable to the UMC, and therefore should not be added to the UMC. Furthermore, the addition of Section 1213.6 and Section 1213.7 were rejected by the UMC TC and the TCC agrees with the UMC TC that the proposed language has not had a public review as it introduces a new concept which was not included in a related proposal as published in the ROP.

The new Section 1213.6 and Section 1213.7 of the UMC will correlate with the action taken by the USEHC TC to “accept as submitted” Item # 045.

The substantiation provided by the USEHC for accepting Item # 045 is as follows:

"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."

Note: The UMC TC rejected the addition of Section 1213.6 and Section 1213.7 in Item # 318 (Public Comment 1). The Committee statement provided by the UMC TC for rejecting Item # 318 (Public Comment 1) is as follows:

"The proposed language has not had a public review as it introduces a new concept which was not included in a related proposal as published in the ROP."

TCC ITEM 29

RECOMMENDATION:

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.
1205.3 Flushing. Heat sources, system piping and tubing shall

404.0 Installation, Testing, and Inspection.
404.1 Operating Instructions. Operating and maintenance information shall be provided to the building owner.
404.2 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 Hav-
be flushed after installation with water or a cleaning solution. Cleaning of the heat source 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. The heat source shall be disconnected from the piping system or protected with a fine mesh strainer during flushing to prevent debris from being deposited into the heat source.

1205.4 Oxygen Diffusion Corrosion. PEX, PE-RT, and PB tubing in closed hydronic systems shall contain an oxygen barrier.

<table>
<thead>
<tr>
<th>x</th>
<th>Accept recommendation as submitted.</th>
</tr>
</thead>
</table>

**404.4 Oxygen Diffusion Corrosion.** PEX, PE-RT, and PB tubing in closed hydronic systems shall contain an oxygen barrier.

**Substantiation:**
The addition of Section 404.0 through Section 404.4 will correlate with the action taken by the UMC TC to “accept as submitted” Item # 309.

**The substantiation provided by the UMC for accepting Item # 309 is as follows:**

“It is imperative that operating and maintenance manuals are provided to the building owner in order to properly operate and maintain the system for future reference. System piping must be tested in order to verify there are no leaks before placing into service and capable of withstanding system operating pressures. This pressure will typically coincide with the set point pressure of the system’s pressure relief devices.

System flushing after installation will eliminate debris from the piping. The cleaning or flushing solution specifically designed for the system will remove fluxes and oils that are still in the system.

Tubing made from thermoplastics allows oxygen molecules to slowly pass through the tube wall and enter the water in the system. This process is called oxygen diffusion. Oxygen corrosion is a very serious corrosion problem in hydronic systems. The dissolved oxygen present in the water when the system is first filled quickly reacts with any iron or steel components. The rate of oxygen diffusion varies for different materials and higher temperatures. The solution to this problem is to create an oxygen diffusion barrier in or on the tubing. One such barrier is a thin layer of a special compound called EVOH (ethylene vinyl alcohol) that is bonded to the tubing during manufacturing. Another type of oxygen barrier is a thin layer of aluminum sandwiched between layers of PEX-AL-PEX. The use of oxygen barrier-equipped tubing does not guarantee that oxygen-related corrosion will not occur. There are several other ways for oxygen to enter a hydronic system such as improperly sized or placed expansion tank, leaky valve seals or pump gaskets, and improperly located air vents. See Code Review Task Group Report 1, Item # 5 where sections are deleted based on duplication of text in the UMC.”

**Note:** The USEHC TC rejected the addition of Section 404.0 through Section 404.4 in Item # 037. The Committee statement provided by the USEHC TC for rejecting Item # 037 is as follows: “The proposed language was rejected as the testing pressure is in conflict with ACI 318.”
### TCC ITEM 30

**RECOMMENDATION:**

<table>
<thead>
<tr>
<th>1220.3 Snow Melt.</th>
<th>416.3 Snow Melt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature, as specified in Section 1213.5. Snow melt auxiliary systems shall be protected from freezing with an approved hydronic solution. The circulating heat transfer fluid shall be a mixture of propylene glycol or ethylene glycol, and water. Automotive antifreeze shall not be used.</td>
<td>An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature in accordance with Section 410.5. Snow melt auxiliary systems shall be protected from freezing with an approved hydronic solution. The circulating heat transfer fluid shall be a mixture of propylene glycol or ethylene glycol, and water. Automotive antifreeze shall not be used.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>x</strong></th>
<th>Accept recommendation as submitted.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject the recommendation.</td>
</tr>
</tbody>
</table>

**Substantiation:**

The revision to Section 1220.3 of the UMC will correlate with the actions taken by the USEHC TC to “accept as modified” Item # 052.

The Committee statement provided by the USEHC TC for accepting Item # 052 as modified is as follows:

“The modification adds “glycol” as it clarifies that propylene glycol and water is a permitted mixture that can be used as a heat transfer fluid.”
RECOMMENDATION:

E 503.4 Mandatory Provisions. Equipment shown in Table E 503.7.1(1) through Table E 503.7.1(13) 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 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) - (11) (remaining text unchanged)
(12) Table E 503.7.1(12) – Commercial Refrigerators and Freezers.
(13) Table E 503.7.1(13) – Commercial Refrigeration.

(remaining text unchanged)
<table>
<thead>
<tr>
<th>EQUIPMENT PROCEDURE CLASS</th>
<th>FAMILY CODE</th>
<th>OPERATING MODE</th>
<th>RATING TEMPERATURE</th>
<th>ENERGY USE LIMITS AS OF 1/1/2012 (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 × TDA + 4.07</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.M</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.83 × TDA + 3.18</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.M</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.35 × TDA + 2.88</td>
<td></td>
</tr>
<tr>
<td>VOP.RC.L</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>2.27 × TDA + 6.85</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.L</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>0.57 × TDA + 6.88</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.M</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.22 × 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 × TDA + 2.61</td>
<td></td>
</tr>
<tr>
<td>SOC.RC.M</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>0.51 × TDA + 0.11</td>
<td></td>
</tr>
<tr>
<td>VOP.SC.M</td>
<td>Vertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>1.74 × TDA + 4.71</td>
<td></td>
</tr>
<tr>
<td>SVO.SC.M</td>
<td>Semivertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>1.73 × TDA + 4.59</td>
<td></td>
</tr>
<tr>
<td>HZO.SC.M</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>0.77 × TDA + 5.55</td>
<td></td>
</tr>
<tr>
<td>HZO.SC.L</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Low temperature</td>
<td>1.92 × TDA + 7.08</td>
<td></td>
</tr>
<tr>
<td>VCT.SC.I</td>
<td>Vertical transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>0.67 × TDA + 3.29</td>
<td></td>
</tr>
<tr>
<td>VCS.SC.I</td>
<td>Vertical solid door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>0.38 × V + 0.88</td>
<td></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.

**TABLE 1701.1**

<table>
<thead>
<tr>
<th>STANDARD NUMBER</th>
<th>STANDARD TITLE</th>
<th>APPLICATION</th>
<th>REFERENCED SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHRI 1200-2013*</td>
<td>Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets</td>
<td>Commercial Refrigerated Display Merchandisers and Storage Cabinets</td>
<td>Table 503.7.1(12, Table 503.7.1(13)</td>
</tr>
</tbody>
</table>

(Portions of table not shown remain unchanged)

X Accept recommendation as submitted. | Reject the recommendation.

**Substantiation:**
Section E 503.4 is being revised to correlate with ASHRAE 90.1-2013 in accordance with IAPMO’s Regulations Governing Committee Projects (Extract Guidelines).
MEMORANDUM

TO: Technical Correlating Committee

FROM: Hugo Aguilar, Staff Liaison

DATE: June 30, 2014

SUBJECT: 2014 TCC Final Ballot Results

Dear Technical Committee Members:

Attached are the Final Ballot Results for the committee actions taken regarding the 2014 TCC Ballot.

13 Members Eligible to Vote
1 Ballot was not received by the closing date of June 26, 2014.
(See voting results for details)

There are two criteria necessary to pass the letter ballot for each item as follows:

1. The number of affirmative votes needed for each item to pass is 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.

The ballot results on all committee actions on comments passed except for the following items:

Item # 022 Failed to achieve the necessary 3/4 affirmative vote of returned ballots (received 8 affirmative).
13 Members eligible to vote - 1 not returned - 0 abstention = 12 x 0.75 = 9.0 or 9 affirmative
13 Members eligible to vote ÷ 2 = 6.5 or 7 simple majority

Please contact me with any questions or comments you may have at 909-472-4111 or Hugo.Aguilar@iapmo.org
<table>
<thead>
<tr>
<th>TCC Item #</th>
<th>Eligible to Vote</th>
<th>Affirmative</th>
<th>Negative</th>
<th>Not Returned</th>
<th>Percent</th>
</tr>
</thead>
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<tr>
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<td>13</td>
<td>12</td>
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<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Affirmative Vote: Achieved 75% affirmative vote passed</td>
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<td></td>
<td></td>
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<tr>
<td>#002</td>
<td>13</td>
<td>12</td>
<td>0</td>
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<td>100%</td>
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<tr>
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<td>Affirmative Vote: Achieved 75% affirmative vote passed</td>
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<td></td>
</tr>
<tr>
<td>#004</td>
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<td>12</td>
<td>0</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Affirmative Vote: Achieved 75% affirmative vote passed</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>100%</td>
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Affirmative Vote: Failed to achieve the necessary ¾ affirmative vote

Negative Comments:
Aguilar/Kreitenberg/Mann/Rodio: I believe the UMC TC was correct in striking this language from Appendix M. The UPC TC should not have accepted this language. Secondly, this is a case where the UMC should prevail and strike this language from the UPC. Furthermore, the substantiation given by the UMC TC is correct.

TCC Item #023 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
Affirmative Vote: Achieved 75% affirmative vote passed

TCC Item #024 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
Affirmative Vote: Achieved 75% affirmative vote passed

TCC Item #025 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
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TCC Item #026 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
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TCC Item #027 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
Affirmative Vote: Achieved 75% affirmative vote passed

TCC Item #028 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
Affirmative Vote: Achieved 75% affirmative vote passed

TCC Item #029 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
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TCC Item #030 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
Affirmative Vote: Achieved 75% affirmative vote passed

TCC Item #031 Eligible to Vote: 13 Affirmative: 12 Negative: 0 Not Returned: 1 Percent: 100%
Affirmative Vote: Achieved 75% affirmative vote passed
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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 fail 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 plans and specifications construction documents shall not prevent the Authority Having Jurisdiction from thereafter requiring the correction of errors in said plans and specifications 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, portable ventilating equipment, a portable cooling unit, or a portable evaporative cooler.
2. A closed system of steam, hot, or chilled water piping or the 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 plans, diagrams, computations, 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 Plans and Specifications Construction Documents. Plans. Construction documents, 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, construction documents, computations, and specifications to 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 plans, 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 plans, 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 plans and specifications 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 Information on Plans and Specifications. Plans and specifications shall be drawn to scale upon substantial paper or cloth and shall indicate the location, nature, and extent of the work proposed and show in detail that it is in accordance with the provisions of this code and relevant laws, ordinances, rules, and regulations.

The Authority Having Jurisdiction shall have the option to accept plans and specifications electronically, in lieu of on cloth or paper, in whatever format it shall require.

104.3.43 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, plans, specifications 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 plans and specifications construction documents “APPROVED.” Such approved plans and specifications 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 plans and specifications 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 plans and specifications 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 plans and specifications, construction documents, and computations shall be retained by the Authority Having Jurisdiction until final approval of the work is covered therein. 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 plans, specifications, 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 plans, specifications, 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 is in accordance with approved plans. The Authority Having Jurisdiction shall make the following inspections and other such inspections as necessary. The permittee or the permittee’s authorized agent shall be responsible for the scheduling of such inspections as follows:

1. Underground inspection shall be made after trenches or ditches are excavated and bedded, piping installed, and before backfill is put in place.
2. Rough-in inspection shall be made prior to the installation of wall or ceiling membranes.
3. Final inspection shall be made upon completion of the installation.

105.2.1 Uncovering. Where a 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, up to and including 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, over 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, up to and including 3 horsepower (hp), or each absorption system up to and including 100,000 Btu/h ................................................................. 1
   - For the installation or relocation of each boiler or compressor exceeding 3 hp, up to and including 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, up to and including 30 hp, or each absorption system exceeding 500,000 Btu/h, up to and including 1,000,000 Btu/h ................................................................. 1
   - For the installation or relocation of each boiler or compressor exceeding 30 hp, up to and including 50 hp, or for each absorption system exceeding 1,000,000 Btu/h, up to and including 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 up to and including 10,000 cubic feet per minute (cfm), including ducts attached thereto .... 1
   - For each air-handling unit exceeding 10,000 cfm ....................................................................................................... 1
   - For each evaporative cooler other than portable type ........................................................................................................ 1

6. Evaporative Coolers
   - For each air-handling unit exceeding 10,000 cfm ....................................................................................................... 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
TABLE 104.5 (continued)
MECHANICAL PERMIT FEES

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-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 exhausted or to improve the quality of the inside air by providing a source of air having a lower concentration of odors, suspended particles, or heat content. [NFPA 96:3.3.2]

Air, Makeup. Air that is provided to replace air being exhausted.

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, Outside. Air from outside the building intentionally conveyed by openings or ducts to rooms or to conditioning equipment.

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]

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.

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 54:3.3.5]

Appliance. A device that utilizes an energy source to produce light, heat, power, refrigeration, or air conditioning. 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 54:3.3.6.4]

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).

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 area/diameter permissible for Category I appliances to maintain a nonpositive vent static pressure where tested in accordance with nationally recognized standards. [NFPA 54:3.3.7]
Apparatus for 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.

Apparatus for Fuel Connector. An assembly of listed semirigid 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 improve 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 a 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. [NFPA 96:3.3.7]

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 \((\frac{dP}{dT})_p = 0\), 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]

Boiler, High-Pressure. A boiler furnishing steam at gauge pressures in excess of 15 pounds-force per square inch (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 (1103 kPa). [NFPA 211:3.3.13.2]

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 70:100.4[D]]

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 5000:3.3.13342.1]

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 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 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 211:3.3.47.1]

Circulators (Circulating Pump). A device that circulates liquids or gases within a closed circuit for an intended purpose.

Classified. See Listed. (Third Party Certified)

Cleaning. 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, roof ceilings, floors, and floor-ceiling assemblies, continuously enclosing a grease duct on four sides where one or more sides require protection in accordance with Section 507.3. [NFPA 96:3.3.14.1]

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 42:3.3.19]

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 5000:3.1.142.2]

Combustible Material. As pertaining to materials adjacent to or in contact with heat-producing appliances, vent connectors, gas vents, chimneys, steam and hot water pipes, and warm air ducts, materials made of or surfaced with wood, compressed paper, plant fibers, or other materials that are capable of being ignited and burned. Such material shall be considered combustible even though flame-proofed, fire-retardant treated, or plastered. [NFPA 54:3.3.67.1]

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 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 1/4 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. [NFPA 96:3.3.477.1] Such spaces have sometimes been used as HVAC plenum chambers.

Condensate. The liquid phase produced obtained from 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 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 96:3.3.242.1]

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 96:3.3.315] 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. 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 that equipment, including associated refrigeration, intended or installed for the purpose of cooling air by mechanical means and discharging such air into any room or space. This definition shall not include any 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 homogeneous 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.

206.0 —D—

Damper. A valve or plate for controlling draft or the flow of gases, including air. [NFPA 211:3.3.51]

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. [NFPA 96:3.3.18]

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 54:3.3.57.1]

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 54:3.3.57.2]

Direct-Vent Appliances. Appliances that are constructed and installed so that air for combustion is derived directly from the outdoors and flue gases are discharged to the outdoors. [NFPA 54:3.3.6.3]

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 96:3.3.198]

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 54:3.3.33]

Duct. A tube or conduit for transmission of air, fumes, vapors, or dusts. This definition shall not include:

1. A vent, vent connector, or chimney connector.
2. A tube or conduit wherein the pressure of the air exceeds 1 psi (7 kPa).
3. The air passages of listed self-contained systems.

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 54:3.3.47.3]

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 96:3.3.240]

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.

207.0 —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 54:42.3.3.36]

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.

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.

Emergency Alarm System. A system intended to provide the indication 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 54:3.3.105.3]

208.0 —F—

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 96:3.3.252.2.1]

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 96:3.3.252.2.2]

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 96:3.3.226]

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 such space. [NFPA 54:3.3.47.5] 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 54:3.3.47.6]

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]

Uplow-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 96:3.3.287]

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 54:3.3.47.1]

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 96:3.3.298] 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.

209.0 –G–

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 54:3.3.50]

Gas Piping. An installation of pipe, valves, or fittings that is 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 definition also shall include floor furnaces equipped with a booster-type fan that does not materially restrict free circulation of air by gravity flow when the fan is 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 96:3.3.30] 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 96:3.3.240.2]

Grease Filter. A removable component of the grease removal system designed to capture grease and direct it to a safe collection point. [NFPA 96:3.3.254.1]

Grease Filter, Mesh-Type. A filter construction consisting of a net made from intersecting strands with a space between each strand. [NFPA 96:3.3.254.2]

Grease Removal Devices. A system of components designed for and intended to process vapors, gases, air, or both 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. [NFPA 96:3.3.342]

Grease-Tight. Constructed and performing in such a manner as not to permit the passage of grease under normal cooking conditions. [NFPA 96:3.3.321]

Grounding Electrode. A conducting object through which a direct connection to earth is established. [NFPA 70:100.4(I)]

210.0 –H–

Hazardous Location. An area or space where combustible dust, ignitable fibers, flammable liquids, volatile liquids, gases, vapors, or mixtures are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Hazardous Process Piping (HPP). A process material piping or tubing conveying a liquid or gas that has a degree-of-hazard rating in health, flammability, or reactivity of Class 3 or 4, as ranked by the fire code.

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.

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.

Heating Degree Day. A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal annual heating load of a building. For any one day when the mean temperature is less than 65°F (18°C), there exist as many degree days as there are Fahrenheit degrees difference in temperature between mean temperature for the day and 65°F (18°C).

Heating Equipment. Includes warm air furnaces, warm air heaters, combustion products vents, heating air-distribution ducts and fans, and all steam and hot water piping, together with all control devices and accessories installed as part of, or in connection with, any environmental heating system or appliance regulated by this code.

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 96:3.3.322]

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.

High Side. 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 96:3.3.343.1]

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.

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 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.

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).
DEFINITIONS

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.

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, Flanged. One made by bolting together a pair of flanged ends.

Joint, Flared. A metal-to-metal compression joint in which a conical spread is made on the end of a tube that is compressed by a flare nut against a mating flare.

Joint, Mechanical. General form for gastight or liquid-tight joints obtained by the joining of parts through a positive holding mechanical construction.

Joint, Soldered. A joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at a temperature up to and including 840°F (449°C).

Joint, Welded. A gastight joint obtained by the joining of metal parts in the plastic molten state.

212.0 –J–

Joint, Compression. A multipiece joint with cup-shaped threaded nuts that, when tightened, compress tapered sleeves so that they form a tight joint on the periphery of the tubing they connect.

Joint, Flanged. One made by bolting together a pair of flanged ends.

Joint, Flared. A metal-to-metal compression joint in which a conical spread is made on the end of a tube that is compressed by a flare nut against a mating flare.

Joint, Mechanical. General form for gastight or liquid-tight joints obtained by the joining of parts through a positive holding mechanical construction.

Joint, Soldered. A joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at a temperature up to and including 840°F (449°C).

Joint, Welded. A gastight joint obtained by the joining of metal parts in the plastic molten state.

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. [NFPA 96:3.3.38.2]

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.

Liquefied Petroleum Gas (LPG) Facilities. Liquefied petroleum gas (LPG) 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.

Liquefied Petroleum Gas (LPG). 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.

Liquid-Tight. Constructed and performing in such a manner as not to permit the passage of liquid at any temperature. [NFPA 96:3.3.365]

Listed (Third Party Certified). Equipment or materials included in a list published by a listing agency (accredited conformity assessment body) that maintains periodic inspection on current production of listed equipment or 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 is 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 testing in which specific information is included that the material or product is in accordance with applicable standards and found safe for use in a specific manner.

**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 Side.** 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 window s. [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 E 136 are considered noncombustible material. [NFPA 220.3.3.4]

(2) Material having a structural base of noncombustible material as defined in 1 above, with a surfacing material not over 1⁄8 of an inch (3.2 mm) thick that has a flame-spread index not higher than 50.

Noncombustible does not apply to surface finish materials. Material required to be noncombustible for reduced clearances to flues, heating appliances, or other sources of high temperature shall refer to material in accordance with 1 above. No material shall be classed as noncombustible that is subject to increase in combustibility or flame-spread index beyond the limits herein established, through the effects of age, moisture, or other atmospheric condition.

**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, AIHA 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.** Comb 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 507.3. [NFPA 96:3.3.14.2]

**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 96:3.3.40] 

Plenum. An air compartment or chamber including uninhabited 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 that 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, 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. 

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. 

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. Poly(vinyl 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. [NFPA 96:3.3.41] 

Quick-Disconnect Device. 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 where the device is disconnected. [NFPA 54:3.3.29.3] 

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.
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 refrigerating system is circulated to the air or other substance to be cooled or heated. [ASHRAE 15:5.1.2]

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.

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 54:3.3.57.6]

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.
DEFINITIONS

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 connects 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 96:3.3.45]

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 96:3.3.46]

Solid-Fuel Cooking Equipment. Cooking equipment that utilizes solid fuel. [NFPA 96:3.3.243.2] This equipment includes ovens, tandoori 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 96:3.3.426]

Spark Arrester. A device or method that minimizes the passage of airborne sparks and embers into a plenum, duct, and flue. [NFPA 96:3.3.498]

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 (\(V_{OD}\)). 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 96:3.3.2019]

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 system and to transfer the thermal energy so reclaimed to a location where a useful purpose can be served. [NFPA 96:3.3.540]

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.

Trap. A cuplike or U-shaped configuration located on the inside of a duct system component where liquids can accumulate. [NFPA 96:3.3.541]

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.

223.0 \[–U–\] 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. Weatherstripping 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.

**224.0 –V–**

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 54:3.3.106.2]

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 54:3.3.108]

**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 54:3.3.6.11.1]

**Category II.** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent. [NFPA 54:3.3.6.11.2]

**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 54:3.3.6.11.3]

**Category IV.** An appliance that operates with a positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent. [NFPA 54:3.3.6.11.4]

**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 54:3.3.47.7]

**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.

**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 ducts 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 REQUIREMENTS

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. 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.

301.4 Electrical Connections. Equipment regulated by this code requiring electrical connections of more than 50 volts shall have a positive means of disconnect adjacent to and in sight from the equipment served. A 120 volt receptacle shall be located within 25 feet (7620 mm) of the equipment for service and maintenance purposes. The receptacle need not be located on the same level as the equipment. Low-voltage wiring of 50 volts or less within a structure shall be installed in a manner to prevent physical damage. 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 or labeled (third-party certified) by a listing agency (accredited conformity assessment body) and shall comply 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.

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 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 accepted mechanical system material standards is referenced in Table 1701.1.

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, durability, and safety over those prescribed by this code. Technical documentation shall be submitted to the Authority Having Jurisdiction to demonstrate equivalency. The Authority Having Jurisdiction shall have the authority to approve or disapprove the system, method, or device for the intended purpose.

However, the exercise of this discretionary approval by the Authority Having Jurisdiction shall have no effect beyond the jurisdictional boundaries of said Authority Having Jurisdiction. An alternate material or method of construction so approved shall not be considered as in accordance with the
requirements, intent, or both of this code for a purpose other than that granted by the Authority Having Jurisdiction where the submitted data does not prove equivalency.

302.2.1 Testing. The Authority Having Jurisdiction shall have authority to require tests, as proof of equivalency.

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 material or device no longer is in accordance with the requirements on which its approval was based.

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

302.3.1 Permit Application. The registered design professional engineer shall indicate on the design documents that the mechanical system, or parts thereof, is an alternative engineered design so that it is noted on the construction permit application. The permit and permanent permit records shall indicate that an alternative engineered design was part of the approved installation.

302.3.2 Technical Data. The registered design professional engineer shall submit sufficient technical data to substantiate the proposed alternative engineered design and to prove that the performance meets the intent of this code.

302.3.3 Design Documents. The registered design professional engineer shall provide two complete sets of signed and sealed design documents for the alternative engineered design for submittal to the Authority Having Jurisdiction. The design documents shall include floor plans of the work. Where appropriate, the design documents shall indicate location, sizing, and loading of appurtenances, equipment, appliances, and devices.

302.3.4 Design Approval. An approval of an alternative engineered design shall be at the discretion of the Authority Having Jurisdiction. The exercise of this discretionary approval by the Authority Having Jurisdiction shall have no effect beyond the jurisdictional boundaries of said Authority Having Jurisdiction. An alternative engineered design so approved shall not be considered as in accordance with the requirements, intent, or both of this code for a purpose other than that granted by the Authority Having Jurisdiction.

302.3.5 Design Review. The Authority Having Jurisdiction shall have the authority to require testing of the alternative engineered design in accordance with Section 302.2.1, including the authority to require an independent review of the design documents by a registered design professional engineer 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 accordance with the submitted testing and inspection plan and the requirements of this code.

303.0 Installation.

303.1 Listed Appliances. Except as otherwise provided in the code, the installation of appliances regulated by this code shall be in accordance with the conditions of listing. The appliance installer shall leave the manufacturer’s installation and operating instructions attached to the appliance. Clearances of listed appliances from combustible materials shall be as specified in the listing or on the rating plate.

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 volume 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 provided in this code, unlisted appliances shall be installed in accordance with the manufacturer’s installation instructions and with the standard clearances from combustible 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 limitations 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 Equipment and Appliances on Roofs. Equipment and 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 not less than a 30 inch (762 mm) clearance between the entire service access panel(s) of the equipment and appliance and the wall of the enclosure. [NFPA 54:9.4.1.1]

303.8.1 Load Capacity. Roofs on which equipment and 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. Access locks, screws, and bolts shall be of corrosion-resistant material. [NFPA 54:9.4.1.3]

303.8.3 Installation of Equipment and Appliances on Roofs. Equipment and appliances shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:9.4.2.1]

303.8.4 Clearance. Equipment and appliances shall be installed on a well-drained surface of the roof. Not less than 6 feet (1829 mm) of clearance shall be between a part of the equipment and or appliance and the edge of a roof or similar hazard, or rigidly fixed rails, guards, parapets, or other building structures not less than 42 inches (1067 mm) in height shall be provided on the exposed side. [NFPA 54:9.4.2.2]

303.8.5 Electrical Power. Equipment and 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 equipment and appliance that will completely de-energize the equipment and appliance.
2. A 120-VAC grounding-type receptacle outlet on the roof adjacent to the equipment and appliance. The receptacle outlet shall be 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 equipment, and appliance or in the passageways to the equipment and appliance, or where the roof is of a design having a water seal, an approved platform, walkway, or both shall be provided above the waterline. Such platforms or walkways shall be located adjacent to the equipment and appliance and control panels so that the equipment and appliance is capable of being 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. 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 manufacturer’s installation instructions.

303.10.1 Clearance Reduction. Where permitted by the manufacturer, reduce 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, reduce clearances to combustible construction for unlisted equipment and appliances shall comply with Table 303.10.1.

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 54:9.2.1.1]

Unless otherwise specified, not less than 30 inches (762 mm) in depth, width, and height of working space shall be provided.

Exception: Unit heaters and room heaters shall be permitted to be installed with an 18 inches (457 mm) minimum depth working space. A platform shall not be required for unit heaters or room heaters. The operating instructions shall be attached to the appliance where they are capable of being read easily.

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 (762 mm) by 30 inches (762 mm) shall be provided at the service side of the equipment or appliance.

304.3 Access to Equipment and Appliances on Roofs. Equipment and 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 trap doors 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.
GENERAL REQUIREMENTS

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

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 center line 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 (762 mm) by 30 inches (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-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]

305.0 Location.

305.1 Installation in Garages. Appliances in 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 burners and burner-ignition devices are located not less than 18 inches (457 mm) above the floor unless listed as flammable vapor ignition resistant. [NFPA 54:9.1.10.1]

305.1.1 Physical Damage. Appliances installed in garages, warehouses, 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 are installed within a garage and are enclosed in a separate enclosed space having access only from outside of the garage, such appliances shall be permitted to be installed at floor level, provided 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.

305.2 Flood Hazard Areas. For buildings located in flood hazard areas, heating, ventilating, air-conditioning, refrigeration, miscellaneous heat-producing, and energy-utilizing equipment and appliances shall be elevated at or above the elevation in accordance with the building code for utilities and attendant equipment or the elevation of the lowest floor, whichever is higher.

Exception: 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.

305.2.1 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, 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.

305.2.2 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 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 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 watertight pan of corrosion-
resistant materials shall be installed beneath the water heater with not less than 1⁄4 of an inch (20 mm) diameter drain to an approved location. Such pan shall be not less than 11⁄2 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 fuel supply to the main burner or burners in the event of pilot or 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 model number or equivalent.
3. The serial number.
4. The type of fuel and pressures applied.
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 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.

Electric heating appliances shall bear a permanent and legible factory-applied nameplate on which shall appear:

1. The name or trademark of the manufacturer.
2. The model number or equivalent.
3. The serial number.
4. The electrical rating in volts, amperes (or watts), and, for other than single phase, the number of phases.
5. The output rating in Btu/h (kW).
6. The electrical rating in volts, amperes, or watts of each field-replaceable electrical component.
7. The symbol of an approved agency certifying compliance of the equipment with recognized standards.
8. Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.

An appliance shall be accompanied by clear and complete installation instructions, including required clearances from combustibles other than mounting or adjacent surfaces, and temperature rating of field-installed wiring connections exceeding 140°F (60°C).

307.3 Heat Pump and Electric Cooling Appliances. Heat pumps and electric cooling appliances shall bear a permanent and legible factory-applied nameplate on which shall appear:

1. The name or trademark of the manufacturer.
2. The model number or equivalent.
3. The serial number.
4. The amount and type of refrigerant.
5. The factory test pressures or pressures applied.
6. The electrical rating in volts, amperes, and, for other than single phase, the number of phases.
7. The output rating in Btu/h (kW).
8. The electrical rating in volts, amperes, or watts of each field replaceable electrical component.
9. The symbol of an approved agency certifying compliance of the equipment with recognized standards.
10. Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.

An appliance shall be accompanied by clear and complete installation instructions, including required clearances from 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. Hourly rating in Btu/h (kW).
6. The type of fuel approved for use with the unit.
7. Cooling capacity Btu/h (kW).
8. Required clearances from combustible surfaces on which or adjacent to which it is permitted to be mounted.
(9) The symbol of an approved agency certifying compliance of the equipment with recognized standards.

308.0 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 is 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, fuel-burning 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 1/4 inch per foot (10.4 mm/m) or 1 percent slope and shall be of approved corrosion-resistant material with a water level detection device installed beneath the cooling coil, or unit, or the appliance top to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow and a separate secondary drain shall be permitted to be provided in lieu of the secondary drain pan.

(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, shall be installed beneath the cooling coil, or unit, or the appliance top to catch the overflow condensate due to a clogged primary condensate drain, or one pan with a standing overflow and a separate secondary drain shall be permitted to be provided in lieu of the secondary drain pan.

(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 standing overflow 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.

This requirement is in addition to the requirements in Section 310.3 and Section 310.4.

310.2.1 Protection of Appurtenances. Where insulation or appurtenances are installed where damage is capable of resulting from a condensate drain pan overfill, such installations shall occur above the rim of the drain pan with supports. Where the supports are in contact with the condensate waste, the supports shall be of approved corrosion-resistant material.

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>
<thead>
<tr>
<th>MINIMUM CONDENSATE PIPE SIZE</th>
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<tbody>
<tr>
<td>EQUIPMENT CAPACITY IN TONS OF REFRIGERATION</td>
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<tr>
<td>-----------------------------------------------</td>
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<tr>
<td>Up to 20</td>
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<tr>
<td>21 – 40</td>
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<tr>
<td>41 – 90</td>
</tr>
<tr>
<td>91 – 125</td>
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<tr>
<td>126 – 250</td>
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</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 1/4 inch per foot (10.4 mm/m) or 1 percent slope, with the pipe running three-quarters full at the following pipe conditions:
Condensate drain sizing for other slopes or other conditions shall be approved by the Authority Having Jurisdiction.

310.3.1 Cleanouts. Condensate drain lines shall be configured or provided with a cleanout to permit the clearing of blockages and for maintenance without requiring the drain line to be cut.

310.4 Fuel-Burning Appliance Condensate Drains. Condensate drain lines from individual fuel-burning 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 airgap or airbreak 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 be listed or labeled in accordance with UL 900. Electrostatic and high efficiency particulate filters shall comply with Section 937.0.

Exceptions:

(1) Systems serving single guest rooms or dwelling units shall not require a listed filter.

311.3 Prohibited Source. Outside or return air for a heating or cooling air system shall not be taken from the following locations:

Outside Air – 20% Room Air – 80%

DB WB DB WB
90°F 73°F 75°F 62.5°F

For SI units: °C = (°F - 32) / 1.8

(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 to be reduced to not less than 50 percent of the required area, provided the balance of the required return air is taken from a room or hall having not less than three doors leading to other rooms served by the furnace.

(5) A closet, bathroom, toilet room, or kitchen.

(6) Rooms or spaces containing a fuel-burning appliance therein. Where such room or space serves as source of return-air.

Exceptions:

(1) This shall not apply to fireplaces, fireplace appliances, residential cooking appliances, direct-vent appliances, enclosed furnaces, and domestic-type clothes dryers installed within the room or space.

(2) This shall not apply to a gravity-type or listed vented wall heating or cooling air system.

(3) This shall not apply to a blower-type heating or cooling air system installed in accordance with the following requirements:

(a) Where the return air is taken from a room or space having a volume exceeding 1 cubic foot (0.03 m³) for each 10 Btu/h (0.003 kW) fuel input rating of fuel-burning appliances therein.

(b) Not less than 75 percent of the supply air is discharged back into the same room or space.

(c) Return-air inlets shall not be located within 10 feet (3048 mm) from an appliance firebox or draft diverter in the same enclosed room or confined space.

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 Pipe, Tube, and Fittings General. Water supply, sanitary drainage, and backflow protection shall be in accordance with the plumbing code. Pipe, tube, and fittings used as supply, drain, hydronics, blowdown, overflow, relief, condensate, or other similar systems shall be of material approved for such use and shall be rated for the operating temperatures and pressures of the system.
213.0 Copper and Copper Alloy Joints and Connections.

213.1 Copper and Copper Alloy Pipe and Joints. Joining methods for copper and copper alloy pipe and fittings shall be installed in accordance with the manufacturer's installation instructions and shall comply with Section 313.1.1 through Section 313.1.3.

213.1.1 Brazed Joints. Brazed joints between copper and copper alloy pipe and fittings shall have a weight of not less than Type L.

Exception: Type M copper tubing shall be permitted to be used where piping is aboveground in, or on, a building or underground outside of structures.

213.2.1 Hard-Drawn Copper and Copper Alloy Tubing. Hard-drawn copper and copper alloy tubing for water supply and distribution, in addition to the required incised marking, shall be marked in accordance with ASTM B88. The colors shall be: Type K, green; Type L, blue; and Type M, red.

213.2.2 Mechanical Joints. Mechanical joints shall include, but are not limited to, compression, flanged, grooved, pressed, and push-fit fittings.

213.2.2.1 Mechanically Formed Tee Fittings. 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 of a depth of 0.19 mm (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.

213.2.2.2 Pressed-Connect Joints. Pressed fittings for copper and 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. Pressed fittings for copper and 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 fitting 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.

213.2.2.3 Push-Connect Joints. Removable and non-removable push-fit fittings for copper pipe or tubing that employ quick-assembly push-fit connectors shall be in accordance with ASSE 1061. Push-fit fittings for copper 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 tubing 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.

213.2.3 Soldered Joints. Solder joints between copper pipe or tubing and fittings shall be made in accordance with the methods of ASTM B88 with the following sequence of joint preparation and operation as follows: measuring and cutting, reaming, cleaning, fluxing, assembly and support, heating, applying the solder, cooling and cleaning. Pipe or tube shall be cut
square and reamed to the full inside diameter including the removal of burrs on the outside of the pipe and 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. Heat shall be applied using an air or fuel torch with the flame perpendicular to the pipe or tubing using acetylene or an LP gas. Preheating shall depend on the size of the joint. The flame shall be moved to the fitting cup and alternate between the pipe or tubing and fitting. 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.-

314.0 313.0 Hangers and Supports.  
314.1 313.1 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.  
314.2 313.2 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.  
314.3 313.3 Suspended Piping. Suspended piping or tubing shall be supported at intervals not to exceed those shown in Table 314.3 313.3.  
314.4 313.4 Alignment. Piping or tubing shall be supported in such a manner as to maintain its alignment and prevent sagging.  
314.5 313.5 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.  
314.6 313.6 Hanger Rod Sizes. Hanger rod sizes shall be not smaller than those shown in Table 314.6 313.6.  

<table>
<thead>
<tr>
<th>PIPE AND TUBE SIZE (inches)</th>
<th>ROD SIZES (inches)</th>
</tr>
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<tbody>
<tr>
<td>½ - 4</td>
<td>⅜</td>
</tr>
<tr>
<td>5 - 8</td>
<td>½</td>
</tr>
<tr>
<td>10 - 12</td>
<td>¾</td>
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For SI units: 1 inch = 25.4 mm

3143.7 Gas Piping. Gas piping shall be supported by metal straps or hooks at intervals not to exceed those shown in Table 1311.2.5.1.

316.0 314.0 Balancing.  
315.1 314.1 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

316.0 315.0 Louvers in Hurricane Prone Regions.  
316.1 315.1 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 (m/h) (49.2 m/s) or greater; or portions of hurricane-prone regions where the basic wind speed is 120 m/h (53.6 m/s) or greater, as described in ASCE 7 shall be tested in accordance with Section 316.1.1 315.1.1 and Section 316.1.2 315.1.2.

316.1.1 315.1.1 Testing. Louvers that protect air intake or exhaust openings shall be tested in accordance with AMCA 550 for resistance to wind-driven rain.

316.1.2 315.1.2 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.

317.0 316.0 Protection of Piping, Tubing, Materials, and Structures.  
317.1 316.1 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.
317.2 316.5 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.

317.3 316.6 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 1 1/2 inches (38 mm) beyond the outside diameter of the pipe or tubing.

Exception: See Section 1311.3.3.

317.4 316.7 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.

317.4.1 316.7.1 Building Loads. Piping or tubing through concrete or masonry walls shall not be subject to a load from building construction.

317.4.2 316.7.2 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 317.2 316.5.

317.4.3 316.8 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.

317.5 316.9 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.

317.6 316.10 Rodentproofing. Mechanical system shall be constructed in such a manner that rats cannot enter as to restrict rodents or vermin from entering a building by following the duct work from the outside into the building.

317.7 316.11 Ductwork or Pipes Metal Collars. In or on buildings where openings have been made in walls, floors, or ceilings for the passage of ductwork or pipes, such openings shall be closed and protected by the installation of approved metal collars securely fastened to the adjoining structure.

318.0 317.0 Trenching, Excavation, and Backfill.

318.1 317.1 Trenches. Trenches deeper than the footings of a building or structure, and paralleling the same, shall be located not less than 45 degrees (0.79 rad) from the bottom exterior edge of the footing, or as approved in accordance with Section 302.0.

318.2 317.2 Tunneling and Driving. Tunneling and driving shall be permitted to be done in yards, courts, or driveways of a building site. Where sufficient depth is available to permit, tunnels shall be permitted to be used between open-cut trenches. Tunnels shall have a clear height of 2 feet (610 mm) above the pipe and shall be limited in length to one-half the depth of the trench, with a maximum length of 8 feet (2438 mm). Where pipes are driven, the drive pipe shall be not less than one size larger than the pipe to be laid.

318.3 317.3 Open Trenches. Excavations required to be made for the installation of a mechanical system or part thereof, within the walls of a building, shall be open trench work and shall be kept open until it has been inspected, tested, and accepted.

318.4 317.4 Excavations. Excavations shall be completely backfilled as soon after inspection as practicable. Precaution shall be taken to ensure compactness of backfill around piping without damage to such piping. Trenches shall be backfilled in thin layers to 12 inches (305 mm) above the top of the piping with clean earth, which shall not contain stones, boulders, cinderfill, frozen earth, construction debris, or other materials that will damage or break the piping or cause corrosive action. Mechanical devices such as bulldozers, graders, etc., shall be permitted to then be used to complete backfill to grade. Fill shall be properly compacted. Precautions shall be taken to ensure permanent stability for pipe laid in filled or made ground.
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<thead>
<tr>
<th>TYPE OF PROTECTION APPLIED TO AND COVERING SURFACES OF COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION [SEE FIGURE 303.10.1(1) THROUGH FIGURE 303.10.1(3)]</th>
<th>WHERE THE REQUIRED CLEARANCE WITH NO PROTECTION FROM APPLIANCE, VENT CONNECTOR, OR SINGLE-WALL METAL PIPE IS:</th>
<th>ALLOWABLE CLEARANCES WITH SPECIFIED PROTECTION (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36 (inches)</td>
<td>18 (inches)</td>
</tr>
<tr>
<td></td>
<td>ABOVE COLUMN 1</td>
<td>SIDES AND REAR COLUMN 2</td>
</tr>
<tr>
<td>(1)</td>
<td>3½ inch thick masonry wall without ventilated air space</td>
<td>—</td>
</tr>
<tr>
<td>(2)</td>
<td>½ of an inch insulation board over 1 inch glass fiber or mineral wool batts</td>
<td>24</td>
</tr>
<tr>
<td>(3)</td>
<td>0.024 inch 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)</td>
<td>3½ inch thick masonry wall with ventilated air space</td>
<td>—</td>
</tr>
<tr>
<td>(5)</td>
<td>0.024 inch sheet metal with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(6)</td>
<td>½ of an inch thick insulation board with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(7)</td>
<td>0.024 inch sheet metal with ventilated air space over 0.024 inch sheet metal with ventilated air space</td>
<td>18</td>
</tr>
<tr>
<td>(8)</td>
<td>1 inch glass fiber or mineral wool batts sandwiched between two sheets 0.024 inch 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(1) 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•°F•h•ft²)] [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.
GENERAL REQUIREMENTS

FIGURE 303.10.1(1)

EXTENT OF PROTECTION NECESSARY TO REDUCE CLEARANCES FROM GAS APPLIANCES OR VENT CONNECTORS

Notes:
1. A – Equals the clearance with no protection specified in Table 802.7.3.4(1) and Table 303.10.1 and in the sections applying to various types of appliances.
2. B – Equals the reduced clearance permitted in accordance with Table 802.7.3.4(1) 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

FIGURE 303.10.1(2)
WALL PROTECTOR CLEARANCE REDUCTION SYSTEM

[NFPA 54: FIGURE 10.3.2.2(b)]

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.

FIGURE 303.10.1(3)
MASONRY CLEARANCE REDUCTION SYSTEM

[NFPA 54: FIGURE 10.3.2.2(c)]
### GENERAL REQUIREMENTS

#### MATERIALS

<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&lt;sup&gt;1,2,3&lt;/sup&gt;</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&lt;sup&gt;1,2,3&lt;/sup&gt;</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&lt;sup&gt;1,2,3,4&lt;/sup&gt;</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>1½ inches and smaller, 6 feet; 2 inches and larger, 10 feet</td>
<td>Each floor, not to exceed 10 feet&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Steel Pipe for DWV</td>
<td>Threaded or Welded</td>
<td>¾ inch and smaller, 10 feet; 1 inch and larger, 12 feet</td>
<td>Every other floor, not to exceed 25 feet&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Steel Pipe for Gas</td>
<td>Threaded or Welded</td>
<td>½ inch, 6 feet; ⅝ inch and 1 inch, 8 feet; ⅛ inches and larger, 10 feet</td>
<td>½ inch, 6 feet; ⅝ inch and 1 inch, 8 feet; ⅛ inches 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&lt;sup&gt;3&lt;/sup&gt;</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; 1½ inches and larger, 4 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>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>PEX</td>
<td>Cold Expansion, Insert and Compression</td>
<td>1 inch and smaller, 32 inches; 1½ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>PEX-AL-PEX</td>
<td>Metal insert and metal compression</td>
<td>½ inch, ⅝ inch, 1 inch</td>
<td>All sizes 98 inches</td>
</tr>
<tr>
<td>PE-AL-PE</td>
<td>Metal insert and metal compression</td>
<td>½ inch, ⅝ inch, 1 inch</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>PE-RT</td>
<td>Insert and Compression</td>
<td>1 inch and smaller, 32 inches; 1½ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>Fusion weld (socket, butt, saddle, electrofusion), threaded (metal threads only), or mechanical</td>
<td>1 inch and smaller, 32 inches; 1½ inches and larger, 4 feet</td>
<td>Base and each floor; provide mid-story guides</td>
</tr>
</tbody>
</table>

**Notes:**

1. Support adjacent to joint, not to exceed 18 inches (457 mm).
2. Brace not to exceed 40 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.

For SI unit: 1 inch = 25.4 mm, 1 foot = 304.8 mm
CHAPTER 4
VENTILATION AIR

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 General Requirements. 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 Healthcare Facilities. Mechanical ventilation for healthcare 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, and 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 mechanical ventilation system is not required where natural ventilation openings comply with the requirements of Section 402.2 and are permanently open or have controls that prevent the openings from being closed during occupancy.
3. A mechanical ventilation system is not required where the zone is not served by heating or cooling equipment. [ASHRAE 62.1:6.4.4]

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, 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 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]

402.2.1.1 Single Side Opening. For spaces with operable openings on one side of the space, the distance from the operable openings shall 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 as 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]

402.2.12 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 operable area of which is a minimum of 4 percent of the net occupiable floor area. Where openings are covered with louvers or otherwise obstructed, operable 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 less than 25 square feet (2.3 m²). [ASHRAE 62.1:6.4.2]

402.2.2 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 wherever 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 inch (6.4 mm) openings, and shall have not more than ½ 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 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.
- $P_z$ = 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]

$$ V_{ot} = \sum_{all \, zones} V_{oz} $$

(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. [ASHRAE 62.1:6.2.5.1]

403.5.2 System Ventilation Efficiency. The system ventilation efficiency ($E_v$) 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]

$$ V_{ou} = D \cdot \sum_{all \, zones} (R_p \cdot P_z) + \sum_{all \, zones} (R_a \cdot A_z) $$

(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.

$$ D = P_s / \sum_{all \, zones} P_z $$

(Equation 403.5.3(2))

Where the system population ($P_s$) is the total population in the area served by the system.
**ASHRAE 62.1:6.2.6.1**  
A* outdoor air averaged over required
Mechanical ventilation systems shall be permitted
Alternative Exhaust Ventilation for
403.7.1.2 Automatic Carbon Monoxide
providing not less than
Ventilation systems shall be designed to be capable of
403.6 Design for Varying Operating Conditions.
the minimum outdoor air intake flow \( V_{ot} \) shall be determined in accordance with Equation 403.5.4. [ASHRAE 62.1:6.2.5.4]

\[
V_{ot} = \frac{V_{ou}}{E_v}
\]

(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 required 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, 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.

\[
T = \frac{3v}{V_{bz}}
\]

(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 (ft³).
- \( V_{bz} \) = the breathing zone outdoor airflow shall be determined in accordance with Equation 403.2.1 and design value of the zone population \( P_z \), cubic foot per minute (cfm).

Acceptable design adjustments based on this optional provision shall be in accordance with 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 \( V_{ot} \) 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 m²) or less and used for the storage of 5 or less vehicles.

**403.7.12 Alternative Exhaust Ventilation for 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. Automatic Carbon Monoxide Sensing Devices. Approved automatic carbon monoxide sensing devices shall be permitted to be employed to modulate the ventilation system to maintain not exceed a maximum average concentration of carbon monoxide of 50 parts per million during an eight-hour period, with a concentration of not more than 200 parts per million 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 \( V_{ot} \), the space or ventilation zone airflow \( V_{oz} \), as operating conditions change. [ASHRAE 62.1:6.2.7]

**403.9 Air Classification and Recirculation.** Air shall be classified, and the recirculation or transfer shall be limited in accordance with Section 403.9.1 through Section 403.9.4. [ASHRAE 62.1:6.2.7] 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 permitted to be recirculated or transferred to Class 1 spaces. Where using an energy recovery device is used, Class 2 air that is recirculated 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 62.1:5.16.3.3]

403.9.3 Class 3 Air. Recirculation of Class 3 air within the same space of origin shall be permitted. Class 3 air shall not be recirculated or transferred to other spaces. Where using an energy recovery device is used, Class 3 that is recirculated 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 other spaces 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 (Ev) where values in Table 403.5.2 are not used. Ev is equal to the lowest calculated value of the zone ventilation efficiency Evz as shown below. 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: Appendix A1.3]

\[ E_v = \min(E_{vz}) \]  
(Equation 404.1)

404.2 Average Outdoor Air Fraction. The average outdoor air fraction (Xv) for the ventilation system shall be determined in accordance with Equation 404.2.

\[ X_v = \frac{V_{ou}}{V_{ps}} \]  
(Equation 404.2)

The uncorrected outdoor air intake (Vou) shall be determined in accordance with Section 403.5.5 and the system primary airflow (Vps) shall be determined at the condition analyzed. [ASHRAE 62.1:A1.1]

404.23 Zone Ventilation Efficiency. The zone ventilation efficiency (Evz) shall be the efficiency with which a system distributes outdoor air from the intake to an individual breathing zone. The zone ventilation efficiency shall be determined in accordance with Section 404.23.1 or Section 404.23.2. [ASHRAE 62.1: Appendix A1.2]

404.23.1 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 (Evz) shall be determined in accordance with Equation 404.23.1. Examples of single supply systems include constant-volume reheat, single-duct VAV, single-fan dual-duct, and multizone systems.

\[ E_{vz} = 1 + X_v - Z_{pz} \]  
(Equation 404.23.1)

The average outdoor air fraction for the system (Xv) for the system shall be determined in accordance with Equation 404.2.1(2) and the primary outdoor air fraction for the zone (Z_{pz}) for the zone shall be determined in accordance with Section 403.5.1. [ASHRAE 62.1:A1.2.1]

\[ X_v = \frac{V_{ou}}{V_{ps}} \]  
(Equation 404.2.1(2))

The uncorrected outdoor air intake (Vou) shall be determined in accordance with Section 403.5.5, and the system primary airflow (Vps) shall be determined in accordance with Section 403.5.3. Examples of single-supply systems include dual-fan dual-duct and fan-powered mixing box systems, and systems that include transfer fans for conference rooms.

\[ E_{vz} = (F_a + X_v F_b - Z_{pz} E_p F_c) / F_a \]  
(Equation 404.23.2(1))

The system air fractions Fa, Fb, and Fc shall be determined in accordance with Equation 404.23.2(2), Equation 404.23.2(3), and Equation 404.23.2(4). The zone primary air fraction (Ep) shall be determined in accordance with Equation 404.23.2(5). For single-zone and single-supply systems Ep shall equal to 1.0. The zone secondary recirculation fraction (Er) shall be determined by the designer based on system configuration. The zone air distribution effectiveness (Ez) 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 404.23.2(2))

\[ F_b = E_p \]  
(Equation 404.23.2(3))

\[ F_c = 1 - (1 - E_z)(1 - E_p)(1 - E_r) \]  
(Equation 404.23.2(4))

\[ E_p = V_{pz} / V_{dz} \]  
(Equation 404.23.2(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.

$F_a$ - 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, cubic feet per minute (L/s).

$V_{pz}$ - 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: A4]
## TABLE 402.1
MINIMUM VENTILATION RATES IN BREATHING ZONE¹, ², ⁴
[ASHRAE 62.1: TABLE 6-1 6.2.2.1]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY⁴</th>
<th>PEOPLE OUTDOOR Air Rate RP (cfm/person)</th>
<th>AREA OUTDOOR Air Rate RA (cfm/ft²)</th>
<th>DEFAULT OCCUPANT Density³ (people/1000 ft²)</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>Day care (through age 4)</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Day care sickroom</td>
<td>10</td>
<td>0.18</td>
<td>25</td>
<td>3</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>Media center⁴</td>
<td>10</td>
<td>0.12</td>
<td>25</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>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</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>0</td>
<td>0.06</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Occupiable storage rooms for liquids or gels³</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</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>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</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>Breakrooms</td>
<td>5</td>
<td>0.12</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>Main entry lobbies</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</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>Freezer and refrigerated spaces (&lt;50°F)</td>
<td>10</td>
<td>0.18</td>
<td>7</td>
<td>3</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>
</tbody>
</table>
### Table 402.1 (continued)

**MINIMUM VENTILATION RATES IN BREATHING ZONE**¹, ², ³

[ASHRAE 62.1: TABLE 6-16.2.2.1]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY⁴</th>
<th>PEOPLE OUTDOOR Air Rate Rₚ (cfm/person)</th>
<th>AREA OUTDOOR Air Rate Rₐ (cfm/ft²)</th>
<th>DEFAULT OCCUPANT Density³ (people/1000 ft²)</th>
<th>AIR CLASS</th>
</tr>
</thead>
<tbody>
<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>
<tr>
<td>Shipping/receivingᵇ</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>7</td>
<td>2</td>
</tr>
<tr>
<td>Telephone closets</td>
<td>–</td>
<td>0.00</td>
<td>–</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>Warehousesᵇ</td>
<td>10</td>
<td>0.06</td>
<td>–</td>
<td>2</td>
</tr>
</tbody>
</table>

**PUBLIC ASSEMBLY SPACES**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<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>30</td>
<td>1</td>
</tr>
<tr>
<td>Libraries</td>
<td>5</td>
<td>0.12</td>
<td>10</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 (children’s)</td>
<td>7.5</td>
<td>0.12</td>
<td>40</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>
</tbody>
</table>

**RESIDENTIAL**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Common corridors</td>
<td>–</td>
<td>0.06</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Dwelling unitᵇ, g</td>
<td>5</td>
<td>0.06</td>
<td>See footnote f</td>
<td>1</td>
</tr>
</tbody>
</table>

**RETAIL**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales (except as below)</td>
<td>7.5</td>
<td>0.12</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Barber shop</td>
<td>7.5</td>
<td>0.06</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Beauty and nail salons</td>
<td>20</td>
<td>0.12</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Coin-operated laundries</td>
<td>7.5</td>
<td>0.12</td>
<td>20</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>Pet shops (animal areas)</td>
<td>7.5</td>
<td>0.18</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Supermarket</td>
<td>7.5</td>
<td>0.06</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

**SPORTS AND ENTERTAINMENT**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowling alley (seating)</td>
<td>10</td>
<td>0.12</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>Disco/dance floors</td>
<td>20</td>
<td>0.06</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>Gambling casinos</td>
<td>7.5</td>
<td>0.18</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td>Game arcades</td>
<td>7.5</td>
<td>0.18</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Gym, sports arena (play area)ᵇ</td>
<td>20</td>
<td>0.18</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Gym, stadium (play area)ᵇ</td>
<td>–</td>
<td>0.30</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>Health club/aerobics room</td>
<td>20</td>
<td>0.06</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>Health club/weight rooms</td>
<td>20</td>
<td>0.06</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Spectator areas</td>
<td>7.5</td>
<td>0.06</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Sports arena (play area)ᵇ</td>
<td>–</td>
<td>0.30</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Stages, studiosᵇ</td>
<td>10</td>
<td>0.06</td>
<td>70</td>
<td>1</td>
</tr>
<tr>
<td>Swimming (pool &amp; deck)ᶜ</td>
<td>–</td>
<td>0.48</td>
<td>–</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. This table applies to no-smoking areas. Rates for smoking-permitted spaces must be determined using other methods.
2. Volumetric airflow rates are based on an 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. 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

UNIFORM MECHANICAL CODE 43
VENTILATION AIR

For high school and college libraries, use values shown for Public Assembly Spaces – Libraries.

Rate is capable of not being sufficient where stored materials include those having potentially harmful emissions.

Rate does not allow for humidity control. Additional ventilation or dehumidification shall be permitted to be required to remove moisture. “Deck area” refers to the area surrounding the pool that would be expected to be 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”).

Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.

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.

Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.

Air from one residential dwelling shall not be recirculated or transferred to other spaces outside of that dwelling.

**TABLE 403.2.2**

ZONE AIR DISTRIBUTION EFFECTIVENESS

<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 at least 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</td>
</tr>
<tr>
<td>Floor supply of cool air and ceiling return provided that the vertical throw is more than 150 fpm supply air jet reaches at a height of less than 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 or return, or both.</td>
<td>0.8</td>
</tr>
<tr>
<td>Makeup supply drawn in near to the exhaust or 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 6-36.2.5.2]

<table>
<thead>
<tr>
<th>MAX ((Z_{p2}))</th>
<th>(E_v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\leq 0.15)</td>
<td>1.0</td>
</tr>
<tr>
<td>(\leq 0.25)</td>
<td>0.9</td>
</tr>
<tr>
<td>(\leq 0.35)</td>
<td>0.8</td>
</tr>
<tr>
<td>(\leq 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 \(Z_{p2}\)” refers to the largest value of \(Z_{p2}\) calculated in accordance with Equation 403.5.1, among the ventilation zones served by the system.

2 For values of Max \((Z_{p2})\) 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 will be capable of yielding more practical results.
### TABLE 403.7
MINIMUM EXHAUST RATES
[ASHRAE 62.1: TABLE 6-4 6.5]

<table>
<thead>
<tr>
<th>OCCUPANCY CATEGORY ¹²</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</td>
<td>–</td>
<td>0.50</td>
<td>2</td>
</tr>
<tr>
<td>Locker/dressing rooms</td>
<td>–</td>
<td>0.25</td>
<td>2</td>
</tr>
<tr>
<td>Paint spray booths</td>
<td>–</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Parking garages¹²</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 rooms⁵</td>
<td>–</td>
<td>–</td>
<td>³</td>
</tr>
<tr>
<td>Residential – kitchens⁴¹²</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 – private⁵²</td>
<td>25/50</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Toilets – public⁵²</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 is not required for open parking garages as defined in accordance with the building code.

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 theatres, schools, and sports facilities. Otherwise the lower rate shall be permitted to be used.

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 rate is not required for enclosed parking garages having a floor area of 1000 square feet (92.9 m²) or less and used for the storage of five or less motorized vehicles.

¹⁰ Exhaust air that has been cleaned in accordance with the criteria of Class 1 shall be permitted to be recirculated.
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 inch (6.4 mm) openings, and shall have not more than 1/2 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 kitchens exhaust ducts shall terminate in accordance with Section 510.9 or Section 510.10.


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 remote 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 dust-proofing. 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 nonsparking 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. 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:
EXHAUST SYSTEMS

(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.

504.2 Independent Exhaust Systems. Single or combined mechanical exhaust systems shall be independent of other exhaust systems.

504.23 Domestic Range Vents. Ducts used for domestic kitchen range ventilation shall be of metal and shall have smooth interior surfaces. Ducts for domestic range hoods shall serve cooking appliances.

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 grease-tight duct.
(4) The duct shall terminate above grade outside the building and shall be equipped with a back-draft damper.

504.3 504.4 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 for that application or installed in accordance with the clothes dryer manufacturer’s installation instructions. Clothes dryer exhaust ducts shall terminate to the outside of the building in accordance with Section 502.2.1 and shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination. Devices, such as fire or smoke dampers, that will obstruct the flow of the exhaust shall not be used. Where joining of ducts, the male end shall be inserted in the direction of airflow.

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]

504.3.2 504.4.2 Type 1 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).

504.3.2.1 504.4.2.1 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.

504.3.2.2 504.4.2.2 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 and flexible clothes dryer transition ducts shall not be concealed within construction, and shall be installed in accordance with the manufacturer’s installation instructions.

504.3.3 504.4.3 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.

504.3.3.4 504.4.3.1 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 504.3.3.4.1 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 Type 2 clothes dryers shall be installed with a 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 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.

504.3.4 504.4.4 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 (305 mm) by 12 inches (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 Standard – Metal and Flexible.

504.4 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 602.5.

505.0 Design of Product-Conveying Ventilation 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 Incompatible Materials. Incompatible materials shall not be conveyed in the same exhaust system. [NFPA 91:4.1.2]

505.1.2 Flammability Limit. In systems conveying flammable vapors, gases, or mists, the concentration shall not exceed 25 percent of the lower flammability limit (LFL).

Exception: Higher concentrations shall be permitted where the exhaust system is designed and protected in accordance with the Standard on Explosion Prevention Systems in Chapter 17, using one or more of the following techniques:

(1) Combustible concentration reduction
(2) Oxidant concentration reduction
(3) Deflagration suppression
(4) Deflagration pressure containment [NFPA 91:4.1.3, 4.1.3.1]

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.

505.1.3 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 Penetrations. Fire dampers shall not be installed where the material being exhausted is toxic and where a risk evaluation indicates that the toxic hazard is more than the fire hazard. Exhaust ducts shall not pass through fire walls. [NFPA 91:4.1.10, 4.1.11]

505.3 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.
### 505.4 Minimum Velocities and Circulation

The velocity and circulation of air in work areas shall be such that contaminants 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 in accordance with Section 505.1.2 with air that does not contain other contaminants. The velocity of air within the duct shall be not less than set forth in Table 505.4. Systems for removal of vapors, gases, and smoke shall be designed by the constant velocity or equal friction methods.

Systems conveying particulate matter shall be designed 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.

### 505.5 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.

### 505.6 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 505.4. Hoods of steel shall have a base metal thickness not less than 0.027 of an inch (0.69 mm) (No. 22 gauge) for Class 1 and Class 5 metal duct systems; 0.033 of an inch (0.84 mm) (No. 20 gauge) for hoods serving a Class 2 duct system; 0.044 of an inch (1.12 mm) (No. 18 gauge) for hoods serving a Class 3 duct system; and 0.068 of an inch (1.73 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.

**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.

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### TABLE 505.4

<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>
</tr>
<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 accordance with NFPA 654.
(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-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.

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 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.

506.4 Explosion Venting. Ducts conveying explosive dusts shall have explosion vents, openings protected by anti-flashback swing valves, or rupture diaphragms. Openings to relieve 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.

506.5 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.

506.5.1 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 91:4.5.1 - 4.5.3]

Exception: Where approved drainage is provided, the weight of the water shall not require consideration.

506.5.2 Corrosion. Hangers and supports exposed to corrosive atmospheres shall be corrosion resistant. [NFPA 91:4.5.4]

506.5.3 Vibration and Stress. To prevent vibration and stress on the duct, hangers and supports shall be securely fastened to the building or structure. [NFPA 91:4.5.5]

506.5.4 Expansion and Contraction. Hangers and supports shall be designed to allow for expansion and contraction. [NFPA 91:4.5.6]

506.6 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.

506.7 Duct Clearances. Ductwork and system components handling combustible material and operating at less than 140°F (60°C) shall have a clearance of not less than 18 inches (457 mm) from combustible construction or a combustible material. [NFPA 91:4.6.2]

Exceptions:

1. Where the ductwork system is operating at less than 140°F (60°C) and is equipped with an approved automatic extinguishing system designed for the specific hazard, the clearance shall be permitted to be reduced to 6 inches.

UNIFORM MECHANICAL CODE
### TABLE 506.2(1)

**MINIMUM SHEET METAL THICKNESS FOR ROUND DUCTS FOR PRODUCT-CONVEYING SYSTEM DUCTS**

<table>
<thead>
<tr>
<th>NEGATIVE PRESSURE (inches water column)</th>
<th>REINF. SPACING (inches)</th>
<th>CLASS 1 (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Up to 7</td>
</tr>
<tr>
<td>0</td>
<td>0.021 (24 ga.)</td>
<td>0.033 (20 ga.)</td>
</tr>
<tr>
<td>8 to 11</td>
<td>0.021 (24 ga.)</td>
<td>0.044 (18 ga.)</td>
</tr>
<tr>
<td>12 to 15</td>
<td>0.021 (24 ga.)</td>
<td>0.055 (16 ga.)</td>
</tr>
<tr>
<td>16 to 19</td>
<td>0.027 (22 ga.)</td>
<td>0.068 (14 ga.)</td>
</tr>
<tr>
<td>20 to 23</td>
<td>0.027 (22 ga.)</td>
<td>0.127 (10 ga.)</td>
</tr>
<tr>
<td>24 to 35</td>
<td>0.027 (22 ga.)</td>
<td>0.127 (10 ga.)</td>
</tr>
<tr>
<td>36 to 47</td>
<td>0.027 (22 ga.)</td>
<td>0.127 (10 ga.)</td>
</tr>
<tr>
<td>8 to 11</td>
<td>0.033 (20 ga.)</td>
<td>0.068 (14 ga.)</td>
</tr>
<tr>
<td>12 to 15</td>
<td>0.033 (20 ga.)</td>
<td>0.097 (12 ga.)</td>
</tr>
<tr>
<td>16 to 20</td>
<td>0.033 (20 ga.)</td>
<td>0.112 (11 ga.)</td>
</tr>
<tr>
<td>20 to 23</td>
<td>0.033 (20 ga.)</td>
<td>0.112 (11 ga.)</td>
</tr>
<tr>
<td>24 to 35</td>
<td>0.033 (20 ga.)</td>
<td>0.112 (11 ga.)</td>
</tr>
<tr>
<td>36 to 47</td>
<td>0.033 (20 ga.)</td>
<td>0.112 (11 ga.)</td>
</tr>
</tbody>
</table>

### CLASS 2 (inches)

| To 7                                    | 0.027 (22 ga.)           | 0.033 (20 ga.)   |
| 8 to 11                                 | 0.027 (22 ga.)           | 0.044 (18 ga.)   |
| 12 to 15                                | 0.027 (22 ga.)           | 0.055 (16 ga.)   |
| 16 to 19                                | 0.027 (22 ga.)           | 0.068 (14 ga.)   |
| 20 to 23                                | 0.027 (22 ga.)           | 0.097 (12 ga.)   |
| 24 to 35                                | 0.027 (22 ga.)           | 0.112 (11 ga.)   |
| 36 to 47                                | 0.027 (22 ga.)           | 0.112 (11 ga.)   |

### CLASS 3 (inches)

| To 7                                    | 0.033 (20 ga.)           | 0.044 (18 ga.)   |
| 8 to 11                                 | 0.033 (20 ga.)           | 0.055 (16 ga.)   |
| 12 to 15                                | 0.033 (20 ga.)           | 0.068 (14 ga.)   |
(152 mm) from combustible materials and ½ of an inch (12.7 mm) from combustible construction. [NFPA 91:4.6.2.1]

(2) Where the combustible material and construction is protected by the use of materials or products listed for protection purposes or in accordance with Table 303.10.1.

506.7.1 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 91:4.6.4.2]

506.7.2 Air Circulation. With clearance reduction systems using a ventilated airspace, air circulation shall be provided as described in Table 303.10.1. There shall be not less than 1 inch (25.4 mm) between the wall protector and combustible walls and ceilings for clearance, reduction systems using a ventilated space.

506.7.3 Wool Batts Insulation. Mineral wool batts (blanket or board) shall have a density of not less than 8 pounds per cubic feet (lb/ft³) (128 kg/m³) and have a melting point of not less than 1500°F (816°C). [NFPA 91:4.6.4.3]

506.7.4 Insulation Board. Insulation board used as a 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)] [0.1 W/(m·K)] or less. Insulation board shall be formed of noncombustible material. [NFPA 91:4.6.4.4]

506.7.5 Clearance with Wall Protector/Surface. There shall be not less than 1 inch (25.4 mm) between the duct and the wall protector. In no case shall the clearance between the duct and the wall surface be reduced below that shown in Table 303.10.1.

506.7.6 High Temperature Duct Systems. Duct systems operating at elevated temperatures exceeding
**TABLE 506.2(2)**

<table>
<thead>
<tr>
<th>NEGATIVE PRESSURE (inches water column)</th>
<th>REINF. SPACING (inches)</th>
<th>LONGEST SIDE OF DUCT</th>
</tr>
</thead>
<tbody>
<tr>
<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>
</tr>
<tr>
<td>To 24</td>
<td>24</td>
<td>0.021 (24 ga.)</td>
</tr>
<tr>
<td>To 12</td>
<td>12</td>
<td>0.021 (24 ga.)</td>
</tr>
</tbody>
</table>

8 to 11

| CLASS 1 (inches) | 0.068 (14 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.033 (20 ga.) | 0.068 (14 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) |
| CLASS 2 (inches) | 0.068 (14 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.033 (20 ga.) | 0.068 (14 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) | 0.097 (12 ga.) |

140°F (60°C) shall have clearances from combustible building construction or combustible materials of not less than 18 inches (457 mm).

**506.7.7 Reduced Clearance.** Where clearance is reduced by using an air gap between the combustible surface and the selected means of protection, air circulation shall be provided by one of the methods in accordance with Section 506.7.7.1 through Section 506.7.7.3. [NFPA 91:4.6.4.7]

**506.7.7.1 Wall Protector.** Air circulation shall be permitted to be provided by leading edges of the wall protecting system open with not less than 1 inch (25.4 mm) air gap. [NFPA 91:4.6.4.7.1]

**506.7.7.2 Single Flat Wall.** Where 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 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 91:4.6.4.7.2]

**506.7.7.3 Wall Protectors that Cover Two Walls.** 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 91:4.6.4.7.3]

**506.8 Protection from Physical Damage.** Ducts installed in locations where they are subject to physical damage shall be protected by guards.
Part II - Commercial Hoods and Kitchen Ventilation.

507.0 General Requirements.

507.1 Exhaust System. Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system in accordance with the equipment and performance requirements of this chapter. [NFPA 96:4.1.1] Such equipment and performance shall be maintained in accordance with this chapter during periods of operation of the cooking equipment. The following equipment shall be kept in good 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 96:4.1.2-4.1.3]

Airflows shall be maintained. [NFPA 96:4.1.4] Maintenance and repairs shall be performed on components at intervals necessary to maintain good working conditions [NFPA 96:4.1.3.1]:

1. The responsibility for inspection, testing, maintenance, and cleanliness of the ventilation control and fire protection of the commercial cooking operations shall be the ultimate responsibility 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]
2. Solid-fuel cooking equipment shall comply with the requirements of Section 517.0. [NFPA 96:4.1.6]
3. Multiple-tenancy 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. Interior surfaces of the exhaust system shall be accessible for cleaning and inspection purposes. [NFPA 96:4.1.8]
5. Cooking equipment used in fixed, mobile, or temporary concessions, such as trucks, buses, trailers, pavilions, tents, or a form of roofed enclosure, shall be in accordance with this chapter unless all or part of the installation is exempted by the Authority Having Jurisdiction. [NFPA 96:4.1.9]

507.2 Listed Devices. Penetrations shall be sealed with listed devices in accordance with the requirements of Section 507.2.1. [NFPA 96:5.1.11]

507.2.1 Penetration. Devices that require penetration of the 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 508.7. Seams, joints, and penetrations of the ductwork shall comply with Section 510.5.2.

507.3 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]

507.3.1 Listed. Where a hood, duct, or grease removal device is listed for clearances less than those in accordance with Section 507.3, the listing requirements shall be permitted. [NFPA 96:4.2.2]

507.3.2 Clearance Reduction. Where a clearance reduction system consisting of 0.013 of an inch (0.33 mm) (22 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]

507.3.2.1 Mineral Wool Batts or Ceramic Fiber Blanket. Where a clearance reduction system consisting of 0.027 of an inch (0.69 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]

507.3.2.2 Zero Clearance. Zero clearance to limited combustible materials shall be permitted where protected by metal lath and plaster, ceramic tile, quarry tile, other noncombustible materials or assembly of noncombustible materials, or materials and products that are listed for the purpose of reducing clearance. [NFPA 96:4.2.3.3]

507.3.3 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]

507.3.3.1 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]

507.3.3.2 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 507.3. [NFPA 96:4.2.4.3]

507.3.3.3 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]
507.3.4 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 "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. The factory-built grease duct protection system shall be listed in accordance with UL 2221. 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] 507.3.5 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 “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 96:4.3.1] 507.3.6 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] 507.3.6.1 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. 507.3.6.2 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] 507.3.6.3 Clearance Options. The following clearance options for which field-applied grease duct enclosures and factory-built grease duct enclosures have been successfully evaluated shall be clearly identified in their listing and installation documentation and on their labels:

(1) Open combustible construction clearance at manufacturer’s requested dimensions.

(2) Closed combustible construction clearance at manufacturer’s requested dimensions, with or without specified ventilation.

(3) Rated shaft clearance at manufacturer’s requested dimensions, with or without specified ventilation. [NFPA 96:4.3.6] 507.3.7 Noncombustible Materials. 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 lineal foot of contact length. [NFPA 96:4.4.1] 507.3.7.1 Corrosion Protection. Where duct contact must exceed the requirements of Section 507.3.7, the duct shall be protected from corrosion. [NFPA 96:4.4.2] 507.3.7.2 Zero Clearance. Where the duct is listed for zero clearance to combustibles or 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 507.3.7 without additional corrosion protection. [NFPA 96:4.4.3] 507.3.8 Clearance Between Duct and Interior Surfaces. Clearances between the duct and interior surfaces of enclosures shall be in accordance with the requirements of Section 507.3. [NFPA 96:4.5] 507.4 Drawings. A drawing(s) of the exhaust system installation along with a copy of operating instructions for subassemblies and components used in the exhaust system, including electrical schematics, shall be on the premises. [NFPA 96:4.6] 507.5 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 Hoods.

508.1 Where Required. Type I hoods shall be installed at or above commercial-type deep-fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines, and similar equipment that produces, emits comparable amounts of steam, smoke, or grease, or other products of combustion, 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. Type II hoods shall be installed above equipment and dishwashers that generate steam, heat, and products of combustion, and where grease or smoke is not present.

Exceptions:

(1) Cooking appliance that is in accordance with UL 7108 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.

(3) Dishwashing machines connected to a Type II duct system and exhausted directly to the outdoors.

(4) 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.

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. [NFPA 96:5.4]

508.42 508.2.1 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 be in accordance with Section 510.0. Ultraviolet hoods shall comply with UL 710 and UL 710C. [NFPA 96:5.5]

508.2.42 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]

508.2.93 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 constructed of steel shall be not less than 0.043 of an inch (1.09 mm) (No. 18 MSG), stainless steel not less than 0.037 of an inch (0.94 mm) (No. 20 MSG) in thickness, or other approved material of equivalent strength and fire and corrosion resistance.

Exception: Listed exhaust hoods.

508.4 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.

508.5 Supports. Hoods shall be secured in place by noncombustible supports. The supports shall be capable of supporting the expected weight of the hood and plus 800 pounds (362.9 kg).

508.6 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]

508.7 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 lower outermost perimeter. [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 to not 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]

508.7.1 Sealed. Internal hood joints, seams, filter support frames, and appurtenances attached inside the hood shall be sealed or otherwise made grease-tight. [NFPA 96:5.1.4]

508.8 Duct Construction 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 508.7.2 508.8. [NFPA 96:5.1.8.1]

508.7.2 508.8.1 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]

508.8 508.9 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]

508.10 Hood Size. Hoods shall be sized in accordance with the airflow capacity in accordance with Section 508.10.1.1 and installed to provide for the removal of heat, and capture and removal of grease-laden vapors in accordance with Section 511.2.

508.10.1 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.

508.10.1.1 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 508.9.1.5 508.10.1.2 through Section 508.10.1.6. Where cooking equipment is installed back to back and is covered by a common island-type hood, the airflow required shall be calculated using the formula for three sides exposed. Type II hood airflow requirements shall be in accordance with the requirements for low-temperature appliance hoods. The exhaust quantity shall be the net exhaust from the hood determined in accordance with Equation 508.10.1.1. 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.

\[
E_{\text{NET}} = E_{\text{HOOD}} - MA_{ID} \quad \text{(Equation 508.10.1.1)}
\]

Where:

- \(E_{\text{NET}}\) = net hood exhaust
- \(E_{\text{HOOD}}\) = total hood exhaust
- \(MA_{ID}\) = makeup air, internal discharge

\(D = \) the horizontal surface area of the hood, in square feet (m²).
\(P = \) that part of the perimeter of the hood that is open, in feet (mm).
\(D = \) distance in feet (mm) between the lower lip of the hood and the cooking surface.
\(Q = \) quantity of air, in cubic feet per minute (m³/s).

508.9.1.2 Solid-Fuel Cooking Equipment. The airflow for solid-fuel cooking equipment, grease burning charbroilers, and undefined equipment shall be not less than the following:

\[\text{Number of Exposed Sides Formula} \]

<table>
<thead>
<tr>
<th>Number of Exposed Sides</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (island or central hood)</td>
<td>(Q = 300A)</td>
</tr>
<tr>
<td>3 or less</td>
<td>(Q = 200A)</td>
</tr>
<tr>
<td>Alternate formula</td>
<td>(Q = 100PD)</td>
</tr>
</tbody>
</table>

508.10.1.2 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 508.10.1.2.

Table 508.10.1.2

<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</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 = 25.4 mm

508.9.1.3 High Temperature Appliances. Type I hoods where the cooking equipment includes high-temperature appliances such as deep-fat fryers:

\[\text{Number of Exposed Sides Formula} \]

<table>
<thead>
<tr>
<th>Number of Exposed Sides</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 (island or central hood)</td>
<td>(Q = 150.4)</td>
</tr>
<tr>
<td>3 or less</td>
<td>(Q = 100.4)</td>
</tr>
<tr>
<td>Alternate formula</td>
<td>(Q = 100PD)</td>
</tr>
</tbody>
</table>

508.10.1.3 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 508.10.1.3.
508.10.1.3 HEAVY-DUTY COOKING APPLIANCE AIRFLOW

<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 = 25.4 mm

508.10.1.4 Medium Temperature Appliances.
Type I hoods, where the cooking equipment includes medium-temperature appliances such as rotisseries, grills, and ranges:

Number of Exposed Sides Formula

\[ Q = 100.4 \sqrt{A} \]

Alternate formula

\[ Q = 50PD \]

508.10.1.4 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 508.10.1.4.

TABLE 508.10.1.4
MEDIUM-DUTY COOKING APPLIANCE AIRFLOW

<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 = 25.4 mm

508.10.1.5 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), and electric and gas steam jackets shall be in accordance with Table 508.10.1.5.

TABLE 508.10.1.5
LIGHT-DUTY COOKING APPLIANCE AIRFLOW

<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>300</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>250</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 = 25.4 mm

508.10.1.6 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.

508.10.2 Noncanopy-Type Hoods.
Noncanopy-type commercial cooking hoods shall be installed and sized in accordance with the manufacturer’s installation instructions, and Section 508.9.2.2 and Section 508.9.2.2.

Exception: Listed hood assemblies designed and installed specifically for the intended use.

508.9.10.2.1 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).

508.9.10.2.2 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 linear foot ([ft³/min]/ft) [0.464 (m³/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.
in accordance with the terms of their listing and the manufacturer’s installation instructions.

508.10 508.11 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, Section 508.7, and Section 508.10. [NFPA 96:5.3.1]

508.10.1 508.11.1 Outer Shell. The construction of the outer shell or the inner exhaust shell shall be in accordance with Section 508.1 and Section 508.7. [NFPA 96:5.3.2]

508.10.2 508.11.2 Inner Shell. Where the outer shell is welded, the inner shell shall be of grease-tight construction. [NFPA 96:5.3.3]

508.10.3 508.11.3 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]

508.10.4 508.11.3.1 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]

508.10.3.2 508.11.3.2 Actuating Temperature. The actuation device shall have a temperature rating not to exceed 286°F (141°C). [NFPA 96:5.3.4.3]

508.10.4 508.11.3.3 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]

508.12 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.

508.13 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.

509.1.1 Grease Filters-Mesh Type. Mesh filters shall not be used unless evaluated as an integral part of a listed exhaust hood or listed in conjunction with a primary filter in accordance with UL 1046.

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 or charcoal-type broilers, including gas or electrically heated charcoal broilers, a 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]

509.2.2 Grease Removal Device Protection. 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, where the distance between the grease removal device and the appliance flue outlet (heat source) is less than 18 inches (457 mm). [NFPA 96:6.2.2.1]

509.2.2.1 Installation. This protection shall 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 exhaust air passes through the grease filters. [NFPA 96:6.2.3.34]
509.2.3.2 Accessibility. Grease filters shall be easily accessible and removable for cleaning removal. [NFPA 96:6.2.3.45]

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 96:6.2.3.46]

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 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, or the hood 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 as practicable to the exterior of the building, so as not to unduly increase a fire hazard. [NFPA 96:7.1.2]

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

510.1.32 Duct Installation. Ducts shall be installed without forming dips or traps that might collect residues. [NFPA 96:7.1.4.4] In manifold (common duct) systems, the lowest end of the main duct shall be connected flush on the bottom with the branch duct. [NFPA 96:7.1.4.45]

Duct systems serving a Type I hood shall be so constructed and installed that grease cannot become pocketed in a portion thereof, and the system shall slope not less than 1/8 inch per lineal foot (20.8 mm/m) toward the hood or toward an approved grease receptacle. Where horizontal ducts exceed 75 feet (22 860 mm) in length, the slope shall be not less than 1 inch per lineal foot (83.3 mm/m).

510.1.43 Accessibility. Openings required for accessibility shall be in accordance with Section 510.3 through Section 510.3.2. [NFPA 96:7.1.5]

510.1.54 Sign. A sign shall be placed on access panels stating the following:

ACCESS PANEL - DO NOT OBSTRUCT [NFPA 96:7.1.6]

510.1.65 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.

510.1.75 Ducts, Non-Grease 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.

510.2 Clearance. Clearance between ducts and combustible materials shall be provided in accordance with the requirements of Section 507.3. [NFPA 96:7.2]

510.2.1 Installation. 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 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 panels that are constructed and installed in accordance with 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 entry 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]

Exception: Dampers that are accessible from under the hood.

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. [NFPA 96:7.3.7]

510.3.3 Horizontal Ducts. On horizontal ducts, not less than 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 this size 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. Openings on horizontal grease duct systems shall be provided with safe access and a work platform where not easily accessible from a 10 feet (3048 mm) stepladder. [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 any point in the duct systems. [NFPA 96:7.4.1.4]
510.3.64 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]

510.3.64.1 Access. Where personnel entry is not possible, an access for cleaning shall be provided on each floor. [NFPA 96:7.4.2.2]

510.3.45 Nonlisted Ductwork. On nonlisted ductwork, the edge of the opening shall not be less than 1 1/2 inches (38 mm) from all outside edges of the duct or welded seams. [NFPA 96:7.4.2.1]

510.3.6 Access Panels. Access panels shall be of the same material and thickness as the duct (Section 510.5.1). Access panels shall have a gasket or sealant that is rated for 1500°F (816°C) and shall be greasetight. 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.

Exception: 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]

510.3.6.1 Within an Enclosure. Where openings are located in ducts within an enclosure, the access panel including its components shall be of the same fire rating as the enclosure.

510.3.7 Fire Protection System Devices. Openings for installation, servicing, and inspection of listed fire protection system devices and for duct cleaning shall be provided in ducts and enclosures and shall be in accordance with the requirements of Section 510.3 through Section 510.3.2, and Section 510.4.6.1 510.7.2. Enclosure openings required to reach access panels in the ductwork shall be large enough for removal of the access panel through the enclosure opening. [NFPA 96:7.4.4]

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]

510.4.1 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 510.5.5.1 510.5.5. [NFPA 96:7.5]

510.5.5.1 Materials. Ducts shall be constructed of and supported by carbon steel not less than 0.024 of an inch (1.37 mm) (No. 16 MSG) in thickness or stainless steel not less than 0.043 of an inch (1.09 mm) (No. 18 MSG) in thickness. [NFPA 96:7.5.1.1]

510.5.21 Factory-Built Grease Ducts. Factory-built grease ducts in accordance with UL 1978 shall be permitted to use materials in accordance with their listing. [NFPA 96:7.5.1.2]

510.5.22 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) Duct-to-hood collar connections as shown in Figure 510.5.2 shall not require a liquid-tight continuous external weld. [NFPA 96:7.5.2.2]

(2) 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 hoods or the ducts structural integrity. [NFPA 96:7.5.2.3]

(3) 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 Pipe Welded Duct Connection. Duct-to-duct connection shall be as follows: (1) Telescoping joint, as shown in Figure 510.5.3.4(1). (2) Bell-type joint, as shown in Figure 510.5.3.4(2). (3) Flange with edge weld, as shown in Figure 510.5.3.4(3). (4) Flange with filled weld, as shown in Figure 510.5.3.4(4). [NFPA 96:7.5.5.1]

510.5.3.6 Butt Welded Connections. Butt welded connections shall not be permitted. [NFPA 96:7.5.5.2]

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

510.5.3.4 fodder 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 adequately 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 507.3. [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]
FIGURE 510.5.3.2
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 510.5.3.4(1)
TELESCOPING -TYPE DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(a)]

For SI units: 1 inch = 25.4 mm

Notes:
1. Duct size stays the same throughout the duct system.
2. Smaller (inside) male duct end is always above or uphill (on sloped duct), to be self-draining into larger (outside) female duct end.

FIGURE 510.5.3.4(2)
BELL-TYPE DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(b)]

FIGURE 510.5.3.4(3)
FLANGE WITH EDGE WELD DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(c)]

FIGURE 510.5.3.4(4)
FLANGE WITH FILLED WELD DUCT CONNECTION
[NFPA 96: FIGURE 7.5.5.1(d)]
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510.87 Interior Installations. In 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 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 and 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 507.3.4 through Section 507.3.6) is protected with a listed duct-through-penetration protection system equivalent to the fire resistance rating of the assembly being penetrated, and the materials are installed in accordance with the conditions of their listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.1.5]

510.87.1 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]

510.87.2 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]

510.87.3 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 507.3.2 are not 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 their listings and the manufacturer’s installation instructions and are acceptable to the Authority Having Jurisdiction. [NFPA 96:7.7.2.2.4]

510.84.1 510.7.4 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]

510.8.4 510.7.5 Materials. For field-applied grease duct enclosures and factory-built grease duct enclosures, the materials and products shall be provided in accordance with Section 510.8.4.1 through Section 510.8.4.3.

510.8.4.2 510.7.5.1 Protection from Physical Damage. Measures shall be taken to prevent physical damage to a covering or enclosure material. A 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]

510.8.4.3 Inspection. In the event of a fire within a kitchen exhaust system, the duct, the enclosure, or 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]

510.8.5 510.7.6 Listed. For listed grease ducts, see Section 510.4.

510.8.6 510.7.7 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 panels shall be readily accessible.

510.8.7 Fire Zone(s) 510.7.8 Ducts with Enclosure(s). A duct system shall constitute an individual system serving 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]

510.78 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 510.5.4.

510.78.1 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.

510.78.2 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 [NFPA 96:7.8.2.1]:

1. Not less than 10 feet (3048 mm) of horizontal clearance from the outlet to adjacent buildings, property lines, and air intakes. [NFPA 96:7.8.2.1(1)] Where space limitations absolutely prevent a 10 foot (3048 mm) horizontal separation from an air intake, a vertical separation shall be permitted, with the exhaust outlet being not less than 2 feet (610 mm) above an air intake located within 10 feet (3048 mm) horizontally.

2. The exhaust flow directed up and away from the surface of the roof and not less than 40 inches (1016 mm) above the roof surface.

3. 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, structurally sound for the service to which it is applied, and will not sustain combustion. A grease collection device that is applied to exhaust systems shall not inhibit the performance of a fan. [NFPA 96:7.8.2.1(4), 7.8.2.1(5)]

Exception: Grease containers that are evaluated for equivalency with the preceding requirements and listed as such.

4. A listed grease duct listed in accordance with Section 510.9.1, or with ductwork constructed in accordance with Section 510.5. [NFPA 96:7.8.2.1(7)]

5. A hinged upblast fan supplied with flexible weatherproof electrical cable and service held-open retainer to permit proper inspection and cleaning that is listed for commercial cooking equipment, provided the ductwork extends not less than 18 inches (457 mm) above the roof surface and the fan discharges not less than 40 inches (1016 mm) above the roof surface. (See Section 511.1.1) [NFPA 96:7.8.2.1(8)]

6. Other approved fan, provided:
   a. It meets the requirements of Section 510.9.1.1(1) and Section 511.1.3.
   b. Its discharge or its extended duct discharge meets the requirements of Section 510.9.1.1(2). (See Section 511.1.3) [NFPA 96:7.8.2.1(9)]

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.

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 non-combustible 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. (See 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 directed perpendicularly outward from the wall face or upward.

3. Ductwork 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 grease duct listed in accordance with Section 510.3.3 through Section 510.3.7, or other ducts constructed in accordance with Section 510.5.

5. An approved fan, provided it meets 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 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.

510.11 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
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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, supplied with flexible weatherproof electrical cable, and service hold-open retainers. (See Figure 511.1.1) Installation shall comply with Section 510.9.

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 grease-tight housing. They 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 96:8.1.3.4 – 8.1.3.6]

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 approved 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 roof termination point shall be in accordance with the following:

(1) Section 510.9.1(1) and Section 510.9.1.2. [NFPA 96:8.1.3.1]

(2) Flexible connectors shall be permitted. [NFPA 96:8.1.3.3.1]

(3) A drain shall be directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L). [NFPA 96:8.1.3.6]

511.1.3.2 Within the Building. Fans installed within the building shall be in accordance with the following:

(1) Located in an easily accessible area of adequate size to allow for service or removal. [NFPA 96:8.1.3.4.2]

(2) Flexible connectors shall be prohibited. [NFPA 96:8.1.3.4.5]

(3) A drain shall be directed to a readily accessible and visible grease receptacle not to exceed 1 gallon (4 L). [NFPA 96:8.1.3.6]

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: 8.1.3.4, 8.1.3.4.4]

511.1.4 Construction. Exhaust fan housings shall be constructed of carbon steel not less than 0.054 of an inch (1.37 mm) (No. 16 MSG) in thickness, of stainless steel not less than 0.043 of an inch (1.09 mm) (No. 18 MSG) in thickness, or, where listed, in accordance with the terms of the listing. [NFPA 96: 8.1.6.4]

511.1.5 Miscellaneous 511.1.4 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 507.3, or Section 510.87.3 where installed within an enclosure. [NFPA 96: 8.1.4.5, 8.1.5.6.2]

511.1.6 Standard. Wiring and electrical equipment shall comply with NFPA 70. [NFPA 96: 8.1.6.7]

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 provided, displayed, or both, upon request. 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 508.9.10.1.3 through Section 508.9.10.1.5. The permit holder shall furnish the necessary test equipment and devices required to perform the tests. [ASHRAE 154:4.8.1]

**511.2.2.2 Capture and Containment Test.** The permit holder shall verify capture and containment performance of the hoods. A field test shall be conducted with the appliance under the hood at operating temperatures, with the source of outdoor air providing makeup air for the hood operating and with the source of recirculated air providing conditioning for the space in which the hood operating is located. Capture and containment shall be verified visually by observing smoke or steam produced by actual or simulated cooking using devices such as smoke candles or smoke puffers. Smoke bombs shall not be used. [ASHRAE 154:4.8.2]

**511.2.3 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 where the exhaust fan and cooking equipment served by the fan have been shut down. [NFPA 96:8.2.3]

**511.3 Makeup Air.** 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 exceeding 0.02 inch water column (0.005 kPa). Where the fire-extinguishing system activates, makeup air supplied internally shall be shut off.

For compensating hoods, where a Type I or Type II hood has an internal discharge of makeup air, the makeup air flow shall not exceed 10 percent of the exhaust airflow, the exhaust airflow shall be the net exhaust from the hood in accordance with Section 508.9.10.1.3 through Section 508.9.10.1.5. 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 outdoor 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., 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 in 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 shall not be installed in ducts. [NFPA 96:9.2.1]

**512.2.1 Device Installation in Ducts.** Where specifically listed for such use motors, lights, and other electrical devices shall be permitted to be installed in ducts or hoods or located in the path of travel of exhaust products. [NFPA 96:9.2.2]
512.2.2 Location 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, hoods or to be located in the path of travel of exhaust products where specifically approved for such use. [NFPA 96:9.3.1] Downgrading other parts of the exhaust system due to the installation of these approved devices, whether listed or not, shall not be allowed permitted. [NFPA 96:9.3.2]

512.3.1 Fire-Extinguishing System. An equipment, listed or otherwise, 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 fire-extinguishing system manufacturer’s installation instructions, for the protection of 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. Filter media used in secondary filtration or air pollution control units and not in accordance 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. Where 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 – 9.3.4]

512.3.2 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]
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 in accordance with UL 300 or other equivalent standards and shall be installed in accordance with the requirements of their listing. [NFPA 96:10.2.8.1]

513.2.5.1 Domestic Water Supply. The water for listed, fixed baffle hood assemblies 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. [NFPA 96:10.2.8.3]

513.2.5.2 Control Valve. The water supply shall be controlled by a supervised water supply control valve. [NFPA 96:10.2.8.4]

513.2.5.3 Activation. The water in the fixed baffle hood specifically listed to extinguish a fire shall be activated by the cooking equipment extinguishing system. [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 instruction and 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. [NFPA 96:10.2.8.6]

513.2.5.5 Exception. Where the fire-extinguishing system provides protection for the cooking equipment, hood, and duct, activation of the water-wash system shall not be required. [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. [NFPA 96:10.2.20]

513.2.6 Water Valve Supervision. Valves controlling the water supply to listed fixed baffle hood assemblies, 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]

513.2.5.1 Automatic Sprinkler System. Simultaneous operation shall not be required where the fixed pipe extinguishing system is an automatic sprinkler system. [NFPA 96:10.3.2]

513.3.2 513.3.1 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 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]

Exception: Solid-fuel cooking operations.

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

513.4.2 Protection Not Required. A gas appliance not requiring protection, but located under the same ventilating equipment, shall also automatically shut off upon activation of an extinguishing system. [NFPA 96:10.4.3]

513.4.32 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, be accessible in the event of a fire, be located in a path of egress, and clearly identify the hazard protected. A manual actuating device shall be located not less than 10 feet (3048 mm) where possible and less than 20 feet (6096 mm) from the protected kitchen appliance(s) within the path of egress. Manual activation using a cable-operated pull station shall require not more than 40 pounds-force (lb) (178 N), 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. [NFPA 96:10.5.1 – 10.5.2]

513.5.4 Location of Manual Activation Device. The manual means of system activation shall be permitted to be common with the automatic means where the manual activation device is located between the control head or releasing device and the first fusible link. [NFPA 96:10.5.3]

513.5.21 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 actuator shall be mechanical or rely on electrical power for activation in accordance with Section 513.5.4. [NFPA 96:10.5.5]
513.5.42 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 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 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 considered obstructions to overhead sprinkler systems and shall not require floor 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]

513.9 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 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 installation instructions, approved design, or both. [NFPA 96:10.9.2]

513.11 Portable Fire Extinguishers. Portable fire extinguishers shall be installed in kitchen cooking areas in accordance with NFPA 10 and shall be specifically listed for such use. Such extinguishers shall use agents that saponify upon contact with hot grease in accordance with NFPA 10 (Class K extinguishers). [NFPA 96:10.10.1, 10.10.2]

513.11.1 Other Fire Extinguishers. Other fire extinguishers in the kitchen area shall be installed in accordance with NFPA 10. [NFPA 96:10.10.3]

513.11.2 Maintenance. Portable fire extinguishers shall be maintained in accordance with NFPA 10. [NFPA 96:10.10.4]

513.11.3 Permitted Use. Portable fire extinguishers listed specifically for use in the kitchen cooking areas shall also be permitted.

513.12 Solid-Fuel Fire-Extinguishing Equipment. Where solid-fuel cooking equipment is served by fire extinguishing equipment, the provisions of Section 517.0 shall apply.

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

514.1 Operating Procedures. Exhaust systems shall be operated where 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 equipment allowed in Section 512.3 shall be conducted by trained and qualified persons at a frequency determined by the manufacturer’s instructions or equipment listing. [NFPA 96:11.1.4.1]

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 trained, qualified, and certified person(s) or company acceptable to the Authority Having Jurisdiction not less than every 6 months. [NFPA 96:11.2.1]

514.2.1 Requirements. 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. In addition to these requirements, 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 Sprinkler Heads. Fusible links of metal alloy type and automatic sprinkler heads of metal alloy type shall be replaced not less than semiannually except as permitted by Section 514.2.3 and Section 514.2.4. [NFPA 96:11.2.4]

514.2.32 Inspection Tag. The year of manufacture and the date of installation of the fusible links shall be marked on the system inspection tag. The tag shall be signed or initialed by the installer. [NFPA 96:11.2.5, 11.2.5.1]

Detection devices that are bulb-type automatic sprinklers and fusible links other than the metal alloy type shall be examined and cleaned or replaced annually. [NFPA 96:11.2.6]

514.2.43 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 operation of the system. [NFPA 96:11.2.7]

514.2.54 Certification. Where required, certificates of inspection and maintenance shall be forwarded to the Authority Having Jurisdiction. [NFPA 96:11.2.8]

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

<table>
<thead>
<tr>
<th>TYPE OR VOLUME OF COOKING</th>
<th>INSPECTION FREQUENCY</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>

514.4 Cleaning of Exhaust Systems. Upon inspection, where 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 trained, qualified, and certified person(s) acceptable to the Authority Having Jurisdiction. [NFPA 96:11.6.1]

514.4.1 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 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]

514.4.3 Fire Suppression System. Components of the fire suppression system shall not be rendered inoperable during the cleaning process. [NFPA 96:11.6.4]

514.4.4 Inoperable. Fire-extinguishing systems shall be permitted to be rendered inoperable during the cleaning process where serviced by 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. Where cleaning procedures are completed, 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. Where 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]
514.10 Airflow. Dampers and diffusers shall be positioned for proper airflow. [NFPA 96:11.6.11]

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

514.12 Certification of Service. Where 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]

514.13 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]

514.14 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]

515.3 514.5 Cooking Equipment Maintenance. Inspection and servicing of the cooking equipment shall be made not less than annually by properly trained and qualified persons. [NFPA 96:11.7.1]

514.35.1 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 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. [NFPA 96:12.1.1]

515.1.1 Installation. Listed appliances shall be installed in accordance with the terms of their listings and the manufacturer’s installation instructions. [NFPA 96:12.1.2.1]

515.1.1.1 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. [NFPA 96:12.1.2.2]

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

515.1.1.4 Minimum Space. Deep-fat fryers shall be installed not less than a 16 inch (406 mm) space between the fryer and surface flames from adjacent cooking equipment. [NFPA 96:12.1.2.4]

515.1.1.5 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 of the adjacent appliance, the requirement for a 16 inch (406 mm) space shall not apply. [NFPA 96:12.1.2.5]

515.1.1.6 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 where the fire 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 507.3.

(2) A hood complying 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: References to ducts in 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 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 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 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 sides, top, and bottom.

4. Electrical connection in the field in accordance with NFPA 70.

5. Interlocks on 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 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 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 Minimum Airflow. An airflow switch or transducer shall be provided after the last filter component to ensure that a minimum airflow is maintained. This device opens the interlock circuit where the airflow falls 25 percent below the system’s normal operating flow or 10 percent below its listed minimum rating, whichever is lower. This 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 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]
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 517.1.65. [NFPA 96:14.1] 

517.1.1 Natural Draft. Where solid-fuel cooking equipment is required by the manufacturer’s instructions to have a natural draft, the vent shall be in accordance with Section 517.4. [NFPA 96:14.1] 

517.1.21 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] 

517.1.32 Makeup Air System. Where the solid-fuel cooking equipment is located in a space with other vented equipment, 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] 

517.1.43 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] 

517.1.64 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] 

517.65 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] 

517.2 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] 

517.2.1 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] 

517.2.2 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] 

517.3 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] 

517.3.1 Separation. 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] 

Exception: Cooking equipment not requiring automatic fire-extinguishing equipment (in accordance with the provisions of 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] 

517.4 Exhaust Systems for Solid-Fuel Cooking. Where a hood is not required, in buildings where the duct system does not exceed three stories in height, a duct complying with Section 510.0 shall be provided. [NFPA 96:14.4] 

517.4.1 Hood. Where a hood is used in buildings where the duct system does not exceed three stories in height, the duct system shall be in accordance with Section 510.0. [NFPA 96:14.4.1] 

517.4.2 Building Exceeding Four Stories. A listed or approved grease duct system shall be provided for solid-fuel cooking exhaust systems that exceed four stories in height. [NFPA 96:14.4.2] 

517.4.3 Prohibition. Wall terminations of solid-fuel exhaust systems shall be prohibited. [NFPA 96:14.4.4] 

517.5 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]
517.6.1 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 the grease removal device to minimize the entrance of these sparks and embers into the grease removal device and into the hood and duct system. [NFPA 96:14.5.2]

517.5.21 Filters. Filters shall be not less than 4 feet (1219 mm) above the appliance cooking surface. [NFPA 96:14.5.3]

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

517.6.1 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]

517.6.2 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]

517.7 Fire-Extinguishing Equipment for Solid-Fuel Cooking. Listed fire-extinguishing equipment shall be provided to protect solid-fuel burning cooking appliances that might be a source of ignition of grease in the hood, grease removal device, or duct.

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, Chapter 2, and Chapter 4, shall not require fixed automatic fire-extinguishing equipment. [NFPA 96:14.7.2]

517.7.1 Grease Removal Devices, Hoods, and Duct Systems. Approved fire-extinguishing equipment shall be provided for the protection of grease removal devices, hoods, and duct systems. [NFPA 96:14.7.2]

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, Chapter 3, and Chapter 4, 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 Standard 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]

517.7.31 Rating and Design. 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 96:14.7.6, 14.7.7]

517.7.4 Listing/Class. Solid-fuel appliances (whether or not under a hood) with fireboxes of 5 cubic feet (0.14 m³) volume or less shall have 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 96:14.7.8]

517.7.62 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]

517.7.6 Fuel Storage. Fuel storage areas shall be provided with a sprinkler system that is installed in accordance with NFPA 13. [NFPA 96:14.9.2.8]

517.7.73 Auxiliary Fuel. In addition to the requirements of Section 517.7.4 through Section 517.7.6, when a solid-fuel cooking appliance is also provided with auxiliary electric, gas, oil, or other fuel for ignition or supplemental heat and the appliance is also served by a portion of a fire-extinguishing system in accordance with Section 513.0, such auxiliary fuel shall be shut off upon actuation of the fire-extinguishing system. [NFPA 96:14.7.11]

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, they 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 Cooking Appliances. Site-built solid fuel cooking appliances shall be submitted for approval to the Authority Having Jurisdiction before being considered for installation. Units 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 arrester required in Section 517.1.65, there shall be no additional devices in a portion of the appliance, flue pipe, and chimney of a natural draft solid-fuel operation. [NFPA 96:14.9.4.4]

517.8.21 Prohibition. No solid-fuel cooking device 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 a deep-fat frying unit. [NFPA 96:14.9.4.5]

518.0 Down Draft Appliances.

518.1 General. A down draft 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 clearance requirements in accordance with Section 507.3.
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 is 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]

518.2 Ventilation System. The ventilation system for a down draft appliance shall be capable of capturing and containing the effluent discharge from the appliance it serves. [NFPA 96:15.1.2]

518.23 Fire-Extinguishing Equipment. Fire-extinguishing equipment for a down draft appliance ventilation system shall comply with the following:

1. Cooking surface, duct, and plenum protection shall be provided.
2. Not less than one fusible link or heat detector shall be installed within the exhaust duct opening in accordance with the manufacturer’s listing.
3. A fusible link or heat detector shall be installed above the protected cooking appliance and in accordance with the extinguishing system manufacturer’s listing.
4. A manual activation device shall be installed as part of the appliance at a height approved by the Authority Having Jurisdiction.
5. Portable fire extinguishers shall be installed in accordance with Section 513.440. [NFPA 96:15.2]

518.23.1 Integral Fire-Extinguishing System. A listed down draft 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 518.23. [NFPA 96:15.2.1]

518.23.2 Interlocks. The down draft 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]

518.34 Airflow Switch or Transducer. An airflow switch or transducer shall be installed after the last filter component to ensure that a minimum airflow is maintained. [NFPA 96:15.3.1]

518.34.1 Interlocks. The airflow switch or transducer shall open the interlock circuit where the airflow is less than 25 percent the system’s normal operating flow or less than 10 percent its listed minimum rating, whichever is less. [NFPA 96:15.3.2]

518.34.2 Manual Reset. The airflow switch or transducer shall be a manual reset device or circuit. [NFPA 96:15.3.3]

518.45 Surface Materials. Surfaces located directly above the cooking appliance shall be of noncombustible or limited-combustible materials. [NFPA 96:15.4]
CHAPTER 6
DUCT SYSTEMS

601.0 General.
601.1 Applicability. Ducts and plenums that are portions of a heating, cooling, absorption or evaporative cooling, or exhaust system shall comply with the requirements of this chapter.
601.2 Sizing Requirements. Duct systems used with blower-type equipment that are portions of a heating, cooling, absorption, evaporative cooling, or outdoor-air ventilation system shall be sized in accordance with an approved standard listed in Table 1701.1, or by other approved methods.

602.0 Material.
602.1 General. Supply air, return air, and outside air for heating, cooling, or evaporative cooling duct systems constructed of metal shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible or UL 181. Concealed building spaces or independent construction within buildings shall 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.

Exceptions:
(1) Return-air and outside-air ducts, plenums, or concealed spaces that serve a dwelling unit shall be permitted to be of combustible construction.
(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) Materials listed and labeled for installation in accordance with Section 602.2.1 through Section 602.2.4.
(6) Smoke detectors.
(7) Duct insulation, coverings, and linings and other supplementary materials installed in accordance with Section 604.0.
(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. Exposed electrical equipment installed within a plenum shall comply with UL 1843.

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 Loudspeakers and Recessed Lighting. Loudspeakers and recessed lighting fixtures, including their assemblies and accessories, in plenums shall be listed and labeled for use in plenums and shall have a peak rate of heat release not exceeding 134 horsepower (hp) (100 kW), an average optical density not exceeding 0.15, and a peak optical density not exceeding 0.5, where tested in accordance with UL 2043.

602.2.5 Discrete Products in Plenums. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

602.3 Metal. Ducts, plenums, or fittings of metal shall comply with SMACNA HVAC Duct Construction Standards - Metal and Flexible or duct systems in accordance with UL 181.

602.4 Existing Metal Ducts. Existing metal ducts shall be permitted to be used where cooling coils are added to a heating system, provided the first 10 feet (3048 mm) of the duct or plenum measured from the cooling coil discharge are constructed of metal of the gauge thickness in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Existing metal ducts completely enclosed in inaccessible concealed areas are not required to be replaced. Accessible ducts shall be insulated in accordance with Section 604.0. For the purpose of this subsection, ducts shall be considered accessible where the access space is 30 inches (762 mm) or greater in height.

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. For the purpose of this section, gypsum products shall not be exposed in ducts serving as supply from evaporative coolers, and in other air-handling systems regulated by this chapter where the temperature of the gypsum product will be below the dew point temperature.
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 isolators 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.

607.15 602.8 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. The pressure classification of ducts shall be not less than the design operating pressure of the air distribution in which the duct is utilized.

603.2 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 with 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.

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.

603.3.1 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.

603.3.2 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 603.3.2.4.

603.3.2.1 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.

603.3.2.2 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.

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

603.3.2.4 Lateral Load. Ducts shall be braced and guyed to prevent lateral or horizontal swing.

603.3.3 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 and Connectors. Factory-made air ducts and connectors shall be listed and labeled in accordance with UL 181 and installed in accordance with 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).

603.4.1 Length Limitation. Factory-made flexible air ducts and connectors shall not be more than 5 feet (1524 mm) in length and shall not be used in lieu of rigid elbows or fittings.

Exception: Residential occupancies.

603.5 Flexible Air Ducts and Connectors. Flexible air ducts and connectors 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 ducts shall not penetrate a fire-resistance-rated assembly or construction. Flexible air connector lengths shall be not more than 5 feet (1524 mm) and shall not penetrate a wall, floor, or ceiling. The temperature of the air to be conveyed in a flexible air duct or connector shall not exceed 250°F (121°C).

603.6 Plastic Ducts. Plastic air ducts and fittings shall be permitted where installed underground and listed for such use.

603.7 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.

603.8 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.

603.9 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.

603.10 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.

Joints and seams and reinforcements for factory-made air ducts and plenums shall comply with the conditions of prior approval in accordance with the installation instructions that shall accompany the product. Closure systems for rigid air ducts and plenums shall be listed in accordance with UL 181A. Closure systems for flexible air ducts shall be listed in accordance with UL 181B.

603.11 Cross Contamination. Exhaust ducts and venting systems under positive pressure shall not extend into or pass through ducts or plenums.

603.12 Underground Installation. Ducts installed underground shall be approved for the installation and shall have a slope of not less than ¾ inch per foot (10.4 mm/m). 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 tightly sealed. Metal ducts where installed in or under a concrete slab shall be encased in not less than 2 inches (51 mm) of concrete.

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.

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 (R-0.6).

(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 (R-0.4); those 5 square feet (0.5 m²) or smaller need not be insulated.

(5) Ducts and plenums used exclusively for evaporative cooling systems.

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.

604.1.2 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 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.

605.0 Smoke Dampers, Fire Dampers, and Ceiling Dampers.
605.1 Smoke Dampers. Smoke dampers shall comply with UL 555S, and shall be installed in accordance with the manufacturer’s installation instructions where required by the building code.

605.2 Fire Dampers. Fire dampers shall comply with UL 555, and shall be installed in accordance with the manufacturer’s installation instructions where required by the building code. Fire dampers shall have been tested for closure under airflow conditions and shall be labeled for both maximum airflow permitted and direction of flow. Where more than one damper is installed at a point in a single air path, the entire airflow shall be assumed to be passing through the smallest damper area.

Ductwork shall be connected to damper sleeves or assemblies in accordance with the fire damper manufacturer’s installation instructions.

605.3 Ceiling Radiation Dampers. Ceiling radiation dampers shall comply with UL 555C, and shall be installed in
accordance with the manufacturer’s installation instructions in the fire-resistive ceiling element of floor-ceiling and roof-ceiling assemblies where required by the building code. Fire dampers not meeting the temperature limitation of ceiling radiation dampers shall not be used as a substitute.

605.4 Multiple Arrangements. Where size requires the use of multiple dampers, the installation shall be framed in an approved manner to ensure that the dampers remain in place.

605.5 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 ½ of an inch (12.7 mm) in height reading as one of the following:

(1) Smoke Damper
(2) Fire Damper
(3) Fire/Smoke Damper

605.6 Freedom from Interference. Dampers shall be installed in a manner to ensure positive closing or opening as required by function. Interior liners 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 to not interfere with the operation or maintenance of external operating devices needed for the function of the damper.

605.7 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.

606.0 Ventilating Ceilings.

606.1 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.

606.2 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.

607.0 Use of Under-Floor Space as Supply Plenum for Dwelling Units.

607.1 General. An under-floor space shall be permitted to be used as a supply plenum.

607.2 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.

607.3 Enclosed. Such spaces shall be cleaned of all loose combustible scrap material and shall be tightly enclosed.

607.4 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.

607.5 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).

607.6 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 where 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).

607.7 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).

607.8 Noncombustible Receptacle. A noncombustible receptacle shall be placed below each floor opening into the air chamber, and such receptacle shall comply with the following sections.

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.

607.9 Floor Registers. Floor registers shall be designed for easy removal in order to give access for cleaning the receptacles.

607.10 Exterior Wall and Interior Stud Partitions. Exterior walls and interior stud partitions shall be fireblocked at the floor.

607.11 Wall Register. Each wall register shall be connected to the air chamber by a register box or boot.

607.12 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.
**607.13 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.

**607.14 Prohibition.** Fuel-gas lines and plumbing waste cleanouts are not located within the space.

**607.16 Concealed Building Spaces.** Concealed building spaces or independent construction within buildings shall be permitted to be used as ducts or plenums. Such concealed space shall not be part of a required fire-resistance-rated construction, used for supply air, and not serve more than one floor level.

**607.16.1 Fireblocking.** Concealed spaces used for the movement of air shall be isolated from adjacent concealed spaces with an approved fireblocking.

**608.0 Automatic Shutoffs.**

**608.1 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 Air for Combustion and Ventilation General.

701.1 General 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 504.3.4. [NFPA 54:9.3.2.3]

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 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 54:9.3.2.2]

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 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 54:9.3.2.2]:

(1) For appliances other than fan-assisted, calculate using Equation 701.4.2(1). [Equation 701.4.2(1)]

Required Volume _other_ ≥ (21 ft³/ACH) x (I_other/1000 Btu/h)

(2) For fan-assisted appliances, calculate using Equation 701.4.2(2). [Equation 701.4.2(2)]

Required Volume _fan_ ≥ (15 ft³/ACH) x (I_fan/1000 Btu/h)

Where:

I_other = Appliances other than fan-assisted input in Btu per hour
I_fan = Fan-assisted appliance input in Btu per hour
ACH = 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) Each opening shall have a free area of not less than 1 square inch per 1000 Btu/h (0.002 m²/kW) of the total input rating of appliances in the space, but not less than 100 square inches (0.065 m²). One opening shall commence within 12 inches (305 mm) of the top of the enclosure and one opening shall commence within 12 inches (305 mm) of the bottom, of the enclosure. (See Figure 701.5.) The dimension of air openings shall be not less than 3 inches (76 mm).

(2) The volumes of spaces in different stories shall be considered as communicating spaces where such spaces are connected by one or more openings in doors or floors having a total free area of not less than 2 square inches per 1000 Btu/h (0.004 m²/kW) of the total input rating of 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:

(1) Where directly communicating with the outdoors or where communicating to the outdoors through vertical ducts, each opening shall have a free area of...
FIGURE 701.5
COMBUSTION AIR FROM ADJACENT INDOOR SPACES THROUGH INDOOR COMBUSTION AIR OPENINGS
[NFPA 54: FIGURE A.9.3.2.3(1)]

FIGURE 701.6.1(1)
COMBUSTION AIR FROM OUTDOORS INLET AIR FROM VENTILATED CRAWL SPACE AND OUTLET AIR TO VENTILATED ATTIC
[NFPA 54: FIGURE A.9.3.3.1(1)(a)]

FIGURE 701.6.1(2)
COMBUSTION AIR FROM OUTDOORS THROUGH VENTILATED ATTIC
[NFPA 54: FIGURE A.9.3.3.1(1)(b)]

FIGURE 701.6.1(3)
COMBUSTION AIR FROM OUTDOORS THROUGH HORIZONTAL DUCTS
[NFPA 54: FIGURE A.9.3.3.1(2)]
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 not less than 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 free area not less than the following:

(1) One square inch per 3000 Btu/h (0.0007 m²/kW) of the total input rating of appliances located in the enclosure.

(2) Not less than the sum of the areas of 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. (See Appendix F for example calculations) [NFPA 54:9.3.4]
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 service 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 not less than 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 be sloped 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 Process Air.

702.1 General. 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, air for compressors; and for comfort and proper working conditions for personnel. [NFPA 54:9.1.7]

703.0 Extra Device or Attachment.

703.1 General. No device or attachment shall be installed on an appliance that is capable of impairing the combustion of gas. [NFPA 54:9.1.15]

704.0 Bleed Lines for Diaphragm-Type Valves.

704.1 General. Bleed lines shall comply with the following requirements:

1. Diaphragm-type valves shall be equipped to convey bleed gas to the outdoors or into the combustion chamber adjacent to a continuous pilot.

2. In the case of bleed lines 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.

3. Bleed lines shall not terminate in the appliance flue or exhaust system.

4. In the case of bleed lines entering the combustion chamber, the bleed line shall be located so the bleed gas will be readily ignited by the pilot and the heat liberated thereby will 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.

5. Bleed lines from a diaphragm-type valve and vent lines from an appliance pressure regulator shall not be connected to a common manifold terminating in a combustion chamber. Bleed lines shall not terminate in positive-pressure-type combustion chambers. [NFPA 54:9.1.20]
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 g Gas vents shall comply with UL 441; Type L gas vents shall comply with UL 641, or UL 1738.

802.1.1 Installation. Listed vents shall be installed in accordance with this chapter and the manufacturer’s installation instructions. [NFPA 54:12.2.3]

802.1.2 Prohibited Discharge. Appliance vents shall not discharge into a space enclosed by screens having openings less than 1/4 of an inch (6.4 mm) mesh.

802.2 Connection to Venting Systems. Except as permitted in Section 802.2.1 through Section 802.2.5, appliances shall be connected to venting systems. [NFPA 54:12.3.1]

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 504.3.
(5) A single listed booster-type (automatic instantaneous) water heater, where 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, where 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 a surface other than the appliance.
(6) Listed refrigerators.
(7) Counter appliances.
(8) Room heaters listed for unvented use.
(9) Direct gas-fired makeup 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.

Where appliances in Section 802.2.1(5) through Section 802.2.1(11) are installed so the aggregate input rating exceeds 20 British thermal units per hour per cubic foot [(Btu/h)/ft³] (0.21 kW/m³) of 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 do not exceed 20 [(Btu/h)/ft³] (0.21 kW/m³). Where the calculation includes the volume of an adjacent room or space, the room or space in which the appliance is 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]

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

802.2.3 Well-Ventilated Spaces. The operation of industrial appliances such that its flue gases are discharged directly into a large and well-ventilated space shall be permitted. [NFPA 54:12.3.4]

802.2.4 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]

802.2.5 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]

802.3 Design and Construction. Venting systems shall be designed and constructed to convey 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. [NFPA 54:12.4.2]
802.3.3 Mechanical Draft Systems. Mechanical draft systems shall be listed 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]

**Exception:** Incinerators.

802.3.3.2 Leakage. Forced draft systems and 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 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 where 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 where the damper is open to a position to properly vent the appliance and where the power means of exhaust is in operation. [NFPA 54:12.4.4.2]

802.3.5 Circulating Air Ducts and Furnace Plenums. Venting systems shall not extend into or pass through a 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]

<table>
<thead>
<tr>
<th>APPLIANCES</th>
<th>TYPE OF VENTING SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed Category I appliance</td>
<td>Type B gas vent (Section 802.6)</td>
</tr>
<tr>
<td>Listed appliance equipped with draft hood</td>
<td>Chimney (Section 802.5)</td>
</tr>
<tr>
<td>Appliance listed for use with Type B gas vent</td>
<td>Single-wall metal pipe (Section 802.7) Listed chimney lining system for gas venting (Section 802.5.3) Special gas vent listed for this appliance (Section 802.4.3)</td>
</tr>
<tr>
<td>Listed vented wall furnaces</td>
<td>Type B-W gas vent (Section 802.6, Section 907.0)</td>
</tr>
<tr>
<td>Category II appliance</td>
<td>As specified or furnished by manufacturers of listed appliance (Section 802.6.3.3)</td>
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<tr>
<td>Category III appliance</td>
<td></td>
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<tr>
<td>Category IV appliance</td>
<td></td>
</tr>
<tr>
<td>Incinerators, outdoors</td>
<td>Single-wall metal pipe (Section 802.7, Section 802.7.2)</td>
</tr>
<tr>
<td>Incinerators, indoors</td>
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</tr>
<tr>
<td>Appliance that is capable of being converted to use of solid fuel</td>
<td>Chimney (Section 802.5)</td>
</tr>
<tr>
<td>Unlisted combination gas- and oil-burning appliance</td>
<td></td>
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<tr>
<td>Combination gas- and solid-fuel-burning appliance</td>
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<tr>
<td>Appliance listed for use with chimneys only</td>
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<tr>
<td>Unlisted appliance</td>
<td></td>
</tr>
<tr>
<td>Listed combination gas- and oil-burning appliance</td>
<td>Type L vent (Section 802.6) or chimney (Section 802.5)</td>
</tr>
<tr>
<td>Decorative appliance in vented fireplace</td>
<td>Chimney (Section 911.2)</td>
</tr>
<tr>
<td>Gas-fired toilets</td>
<td>Single-wall metal pipe (Section 802.7, Section 930.3)</td>
</tr>
<tr>
<td>Direct-vent appliance</td>
<td>See Section 802.2.4</td>
</tr>
<tr>
<td>Appliance with integral vent</td>
<td>See Section 802.2.5</td>
</tr>
</tbody>
</table>

802.4.1 Plastic Piping. Plastic piping used for venting appliances listed for use with such venting materials shall be approved. [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. Where primer is required, it shall be of a contrasting color. [NFPA 54:12.5.3]

802.4.3 Special Gas Vent. Special gas vent shall be listed 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 manufac-
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 clay flue lining, a listed chimney lining system, or other approved material that resists corrosion, erosion, softening, or cracking from vent gases at temperatures not exceeding 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). (See Figure 802.5.4) [NFPA 54:12.6.2.1]

**802.5.4.1 Medium-Heat Gas Appliances.** A chimney for a medium-heat appliance shall extend not less than 10 feet (3048 mm) above a portion of a building within 25 feet (7620 mm). [NFPA 54:12.6.2.2]

**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 [NFPA 54:12.6.3.1]:

1. Section 803.0. [NFPA 54:12.6.3.1(1)]
2. For sizing an individual chimney venting system for a single appliance with a draft hood, the effective area of the vent connector and chimney flue shall be not less than the area of the appliance flue collar or draft hood outlet or exceeding seven times the draft hood outlet area. [NFPA 54:12.6.3.1(2)]
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 exceeding seven times the smallest draft hood outlet area. [NFPA 54:12.6.3.1(3)]
4. Other approved engineering methods. [NFPA 54:12.6.3.1(4)]
5. Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods. [NFPA 54:12.6.3.1(5)]

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 passage-way 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 where an appliance is replaced by an appliance of similar type, input rating, and efficiency, where the chimney is in accordance with Section 802.5.7, 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 they will remain tightly closed where not in use. [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 NFPA 211, and shall be approved for the appliances 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 Multiple 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 Manual Reset Device. 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 the appliance. [NFPA 54:12.6.5.4]

802.5.9 Support of Chimneys. Portions of chimneys shall be supported for the design and weight of the materials employed. Listed factory-built chimneys shall be supported and spaced in accordance with the manufacturer’s 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. Gas vents shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:12.7.1(1)]

802.6.1 Fasteners. 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 54:12.7.1(4)]

802.6.2 Termination Requirements. A gas vent shall terminate in accordance with one of the following:

1. Gas vents that are 12 inches (305 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 802.6.2 and Table 802.6.2. Gas vents that are over 12 inches (305 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.

2. Industrial appliances provided in Section 802.2.3.

3. Direct-vent systems as provided in Section 802.2.4.

4. Appliance with integral vents as provided in Section 802.2.5.

5. Mechanical draft systems as provided in Section 802.3.3.

6. Ventilating hoods and exhaust systems as provided in Section 802.3.4. [NFPA 54:12.7.2(1)]

802.6.2.1 Type B and L Vents. A Type B or a Type L gas vent shall terminate not less than 5 feet (1524 mm) in vertical height above the highest connected appliance draft hood or flue collar. [NFPA 54:12.7.2(2)]

802.6.2.2 Type B-W Vents. A Type B-W gas vent shall terminate not less than 12 feet (3658 mm) in vertical height above the bottom of the wall furnace. [NFPA 54:12.7.2(3)]

802.6.2.3 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 802.2.4 and Section 802.3.3. [NFPA 54:12.7.2(4)]

802.6.2.4 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)]

802.6.2.5 Termination Cap. A gas vent 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)]

802.6.2.6 Forced Air Inlet. A gas vent shall terminate not less than 3 feet (914 mm) above a forced air inlet located within 10 feet (3048 mm). [NFPA 54:12.7.2(7)]

802.6.2.7 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.

802.6.3 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 and appliance manufacturer’s instructions. [NFPA 54:12.7.3]

802.6.3.1 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.

(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]

802.6.3.2 Vent Offsets. Type B or Type L vents shall extend in a vertical direction with offsets not exceeding 45 degrees (0.79 rad), except that a vent system having not more than one 60 degree (1.05 rad) offset shall be permitted. An angle greater than 45 degrees (0.79 rad) 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 exceed 75 percent of the vertical height of the vent. [NFPA 54:12.7.3.2]

802.6.3.3 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. [NFPA 54:12.7.3.3]

802.6.3.4 Sizing. Chimney venting systems using mechanical draft shall be sized in accordance with approved engineering methods. [NFPA 54:12.7.3.4]

802.6.4 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]

802.6.4.1 Occupiable Space. 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. (See Figure 802.6.4.1) [NFPA 54:12.7.4.2]

802.6.4.2 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 803.1.3(7), provided the following apply:

(1) The 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. (See Figure 802.6.4.2)

(2) The size of the connector for a segment is determined from the appliance’s gas input rate and 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, shall be based on the total appliance’s gas input rate entering that segment and its total height. [NFPA 54:12.7.4.3]

**802.6.5 Support of Gas Vents.** Gas vents shall be supported and spaced in accordance with the manufacturer’s installation instructions. [NFPA 54:12.7.5]

**802.6.6 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]

**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 comply with the following requirements:

1. Single-wall metal pipe shall terminate not less than 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 not less than 2 feet (610 mm) above the highest point where it passes through a roof of a building and not less than 2 feet (610 mm) exceeding a 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 Table 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 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 an unoccupied attic or concealed space and shall not pass through an attic, inside wall, concealed space, or floor. [NFPA 54:12.8.4.3]

**802.7.3.3 Incinerator.** Single-wall metal pipe used for venting an incinerator shall be exposed and readily examinable for its full length and shall have required clearances maintained.

**802.7.3.4 Clearances.** Minimum clearances from single-wall metal pipe to combustible material shall be in accordance with Table 802.7.3.4(1). Reduced clearances from single-wall metal pipe to combustible material shall be as specified for vent connectors in Table 303.10.1. [NFPA 54:12.8.4.5]

**802.7.3.5 Combustible Exterior Wall.** A 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,

2. Listed appliance with draft hoods and appliance listed for use with Type L gas vents

<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.
thimble shall be not less than 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 not less than 2 inches (51 mm) larger in diameter than the metal pipe.

2. For unlisted appliances having draft hoods, the thimble shall be not less than 6 inches (152 mm) larger in diameter than the metal pipe.

3. For residential and low-heat appliances, the thimble shall be not less than 12 inches (305 mm) larger in diameter than the metal pipe.

**Exception:** In lieu of thimble protection, combustible material in the wall shall be removed from the metal pipe to provide the specified clearance from combustible material. Material used to close up such opening shall be noncombustible. [NFPA 54:12.8.4.6]

**802.7.3.6 Roof Thimble.** Where a single-wall metal pipe passes through a roof constructed of combustible material, a noncombustible, nonventing thimble shall be used at the point of passage. The thimble shall extend not less than 18 inches (457 mm) above and 6 inches (152 mm) below the roof with the annular space open at the bottom and closed at the top. The thimble shall be sized in accordance with Section 802.7.3.5. [NFPA 54:12.8.4.6]

**802.7.4 Size of Single-Wall Metal Pipe.** Single-wall metal piping shall comply with the following sections. [NFPA 54:12.8.5]

**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 seven times the draft hood outlet area.

3. Other approved engineering methods. [NFPA 54:12.8.5(1)]

**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 effective area equal to the effective area of the round pipe for which it is substituted, and the 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.** 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 802.6.6. [NFPA 54:12.8.7]

**802.8 Through-the-Wall Vent Termination.** A mechanical draft venting system shall terminate not less than 3 feet (914 mm) above a forced air inlet located within 10 feet (3048 mm).

**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 shall be located not less than 6 inches (152 mm) from an air opening into a building, and such an appliance with an input over 10 000 Btu/h (3 kW) but not exceeding 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 not less than a 12 inch (305 mm) vent termination clearance. The bottom of the vent terminal and the air intake shall be located not less than 12 inches (305 mm) above finished ground level. [NFPA 54:12.9.3]

**802.8.3 Nuisance and Hazard.** 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 is capable of creating a nuisance or hazard that is 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 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 terminals 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 exceeding that of (b), (c), or (d) above.
   (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 non-residential low-heat appliance shall be a factory-built chimney section or steel pipe having resistance to heat and corrosion equivalent to the galvanized pipe specified in Table 802.10.1.3. Factory-built chimney sections shall be installed in accordance with the chimney manufacturer’s installation instructions. [NFPA 54:12.11.2.5]

| TABLE 802.10.1.3 MINIMUM THICKNESS FOR GALVANIZED STEEL VENT CONNECTORS FOR LOW-HEAT APPLIANCES [NFPA 54: TABLE 12.11.2.5] |
|---------------------------------|------------------|
| DIAMETER OF CONNECTOR (inches) | MINIMUM THICKNESS (inches) |
| Less than 6                    | 0.019            |
| 6 to less than 10              | 0.023            |
| 10 to 12 inclusive             | 0.029            |
| 14 to 16 inclusive             | 0.034            |
| Over 16                        | 0.056            |

For SI units: 1 inch = 25.4 mm, 1 square inch = 0.000645 m²

802.10.1.4 Medium-Heat Appliances. Vent connectors for medium-heat appliances, and commercial and industrial incinerators, shall be constructed of factory-built, medium-heat chimney sections or steel of a thickness not less than that specified in Table 802.10.1.4, and shall comply with the following:

(1) A steel vent connector for appliances 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 not less than 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 not less than 4½ inches (114 mm) thick laid on the 4½ inches (114 mm) bed for a vent connector having diameter or greatest cross-sectional dimension exceeding 18 inches (457 mm).
CHIMNEYS AND VENTS

(4) Factory-built chimney sections, where employed, shall be installed in accordance with the chimney manufacturer’s installation instructions. [NFPA 54:12.11.2.6]

**TABLE 802.10.4**
MINIMUM THICKNESS FOR STEEL VENT CONNECTORS FOR MEDIUM-HEAT APPLIANCES AND COMMERCIAL AND INDUSTRIAL INCINERATORS
[NFPA 54: TABLE 12.11.2.6]

<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>
<td>201 to 254</td>
<td>0.093</td>
<td></td>
</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 appliances 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 54:12.11.3.1]

**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 alternate 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 not less than 1 foot (305 mm) rise. [NFPA 54:12.11.3.2]

**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 alternate method applicable where 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 shall be sized in accordance with Section 803.0 or other approved engineering methods. [NFPA 54:12.11.3.5]

As an alternate method applicable where there are two draft hood-equipped appliances, the effective area of the common vent connector or vent manifold and junction fittings shall be not less than the area of the larger vent connector plus 50 percent of the areas of smaller flue collar outlets. [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 the openings shall be at different levels, or the connectors shall be attached to the vertical portion of the chimney or vent at an angle of 45 degrees (0.79 rad) 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 a 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 802.7.3.4(1).

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. By sheet metal screws.
2. Vent connectors of listed vent material shall be assembled and connected to flue collars or draft hood outlets in accordance with the manufacturer’s installation instructions.
3. Other approved means. [NFPA 54:12.11.6]

**802.10.6 Slope.** A vent connector shall be installed without dips or sags and shall slope upward toward the vent or chimney not less than ¼ inch per foot (20.8 mm/m).

Exception: Vent connectors attached to a mechanical draft system installed in accordance with the appliance and draft system manufacturer’s installation 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 and 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 54:12.11.9.2]

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 54:12.11.9.3]

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 54:12.11.10]

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 54:12.11.11]

802.10.10 Inspection. The entire length of a vent connector shall be readily accessible for inspection, cleaning, and replacement. [NFPA 54:12.11.12]

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 54:12.11.13]

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 54:12.11.14.2]

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 comply with Section 802.4. [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.

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.

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]

802.12.2 Draft Control Devices. Where a draft control device is part of the appliance or is 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 a 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 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 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 appliance vent connector. Fixed baffles shall not be classified as manually operated dampers. [NFPA 54:12.14]

802.14 Automatically Operated Vent Dampers. An automatically operated vent damper shall be of a listed type. [NFPA 54:12.15]

802.14.1 Listing. Automatically operated vent dampers for oil-fired appliances shall comply with UL 17. The automatic damper control shall comply with UL 378.

802.15 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 and 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). These venting tables 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 \((0.90 \times \text{maximum table capacity})\).

(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 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 lengths, including 90 degree (1.57 rad) elbows. For each additional elbow up to and including 45 degrees \((0.79 \text{ rad})\), the maximum capacity listed in the venting tables shall be reduced by 5 percent. For each additional elbow greater than 45 degrees \((0.79 \text{ rad})\) up to and including 90 degrees \((1.57 \text{ rad})\), 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 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 \((\text{FAN Min})\) determined from the tables shall be less than the lowest appliance input rating, and the maximum vent capacity \((\text{FAN Max}/\text{NAT Max})\) 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 \((0.80 \times \text{maximum capacity})\) 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 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 802.6.2, the outdoor portion of the vent shall be enclosed as required by this section for vents not considered to be exposed to the outdoors. Table 803.1.2(6) in combination with Table 803.1.2(6) shall be used for clay-tile-lined exterior masonry chimneys, provided the following requirements are met:

1. The vent connector is Type B double wall.
2. The vent connector length is limited to 18 inches/inch (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 exceeds 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 C 315 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 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 exceeding vent heights 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), 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 v appliance input rating for the FAN MIN column values. [NFPA 54:13.1.18]

803.2 Multiple Appliance Vent Table 803.1.2(7) through Table 803.1.2(15). These venting tables 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 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 where the second appliance is a fan-assisted appliance, or the NAT + NAT column where the second appliance is equipped with a draft hood.
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 where the second appliance is a fan-assisted appliance, and the FAN + NAT column shall be used where 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 length listed for a 4 inch (102 mm) connector shall not exceed 6 feet (1829 mm). With a connector length exceeding 6 feet (1829 mm) but not exceeding 12 feet (3658 mm), the maximum capacity shall be reduced by 10 percent (0.90 x maximum vent connector capacity). With a connector length exceeding 12 feet (3658 mm) but not exceeding 18 feet (5486 mm), the maximum capacity shall 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 though the other appliances were not present. [NFPA 54:13.2.3]

**803.2.3 Ten Percent Reduction.** 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 802.6.4.2) [NFPA 54:13.2.4]

**803.2.4 Vent Offset.** 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 Elbow Reduction.** 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 Common Vent Minimum Size.** The cross-sectional area of the common vent shall be equal to or exceed the cross-sectional area of the largest connector. [NFPA 54:13.2.7]

**803.2.7 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]

**803.2.8 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]
803.2.9 **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 54:13.2.11]

803.2.10 **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]

803.2.11 **Vent Height.** For multiple appliances located on one floor, the 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]

803.2.12 **Multistory Installations.** For multistory installations, the 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 803.2.12) [NFPA 54:13.2.14]

803.2.13 **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 803.1.2(2) for available total height \((H)\) up to the lowest interconnection. (See Figure 803.2.13) [NFPA 54:13.2.15]

803.2.14 **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]

803.2.15 **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 \((0.80 \times \text{maximum common vent capacity})\).
4. A multistory common vent shall not be reduced in size above the offset. [NFPA 54:13.2.17]

803.2.16 **Flow Area of Vent.** 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]
803.2.17 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 the highest appliance input rating. [NFPA 54:13.2.19]

803.2.18 Corrugated Metallic Chimney Liner Reduction. Listed, corrugated metallic chimney liner systems in masonry chimneys shall be sized by using Table 803.1.2(7) or Table 803.1.2(8) 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(7) or Table 803.1.2(8). Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Section 803.2.4 and Section 803.2.5. 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]

803.2.19 Chimneys and Vents. Table 803.1.2(7) through Table 803.1.2(11) shall be used 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 R-8 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 802.6.2, and where vents terminate in accordance with Section 802.6.2, 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 803.1.2(12) through Table 803.1.2(15) shall be used for clay-tile-lined exterior masonry chimneys, provided the following conditions are met:

1. The vent connector is Type B double-wall.
2. Not less than one appliance is draft hood-equipped.
3. The combined appliance input rating is less than the maximum capacity given by Table 803.1.2(12) (for NAT+NAT) or Table 803.1.2(14) (for FAN+NAT).
4. The input rating of each space-heating appliance exceeds the minimum input rating given by Table 803.1.2(13) (for NAT+NAT) or Table 803.1.2(15) (for FAN+NAT).
5. The vent connector sizing is in accordance with Table 803.1.2(9). [NFPA 54:13.2.22]

803.2.20 Vent Connector Size Limitations. Vent connectors shall not be increased more than two sizes exceeding 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 vent connector sizes determined from the tables for fan-assisted appliances are smaller than the flue collar diameter, the use of the smaller sizes shall be permitted provided that the installation is in accordance with the following conditions:

1. Vent connectors for fan-assisted appliance flue collars 12 inches (305 mm) in diameter or smaller are not reduced by more than one table size [e.g., 12 inches to 10 inches (305 mm to 254 mm) is a one-size reduction] and those exceeding 12 inches (305 mm) in diameter are not reduced exceeding two table sizes [e.g., 24 inches to 20 inches (610 mm to 508 mm) is a two-size reduction].
2. The fan-assisted appliance is common vented with a draft hood-equipped appliance.
3. The vent connector has a smooth interior wall. [NFPA 54:13.2.24]
803.2.21 Combination of Pipe Types and Sizes. Combinations of pipe sizes, single-wall metal pipe, and double-wall metal pipe shall be allowed within a connector run or within the common vent, provided the appropriate tables permit the desired sizes and types of pipe, where 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 in accordance with Table 803.1.2(8) or Table 803.1.2(10). [NFPA 54:13.2.25]

803.2.22 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]

803.2.23 Interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries. [NFPA 54:13.2.27]

803.2.24 Extrapolation. Extrapolation beyond the table entries shall not be permitted. [NFPA 54:13.2.28]

803.2.25 Engineering Methods. For vent heights lower than 6 feet (1829 mm) and exceeding vent heights shown in the tables, engineering methods shall be used to calculate vent capacities. [NFPA 54:13.2.29]

803.2.26 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(7) through Table 803.1.2(15), 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]

---

**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]

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 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
### TABLE 803.1.2(1)
**TYPE B DOUBLE-WALL GAS VENT [NFPA 54: TABLE 13.1(a)]**

<table>
<thead>
<tr>
<th>VENT DIAMETER – D (inch)</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
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<tbody>
<tr>
<td><strong>HEIGHT H (feet)</strong></td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
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<tr>
<td><strong>LATERAL L (feet)</strong></td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td><strong>NUMBER OF APPLIANCES:</strong></td>
<td>SINGLE</td>
<td>CATEGORY I</td>
<td>CONNECTED DIRECTLY TO VENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR</strong></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
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<tr>
<td><strong>NUMBER OF APPLIANCES:</strong></td>
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<td>CATEGORY I</td>
<td>CONNECTED DIRECTLY TO VENT</td>
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<td></td>
</tr>
<tr>
<td><strong>APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR</strong></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
<td>Min</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

* NA: Not applicable.

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(1)**

**TYPE B DOUBLE-WALL GAS VENT [NFPA 54: TABLE 13.1(a)] (continued)**

<table>
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<tr>
<th>HEIGHT $H$ (feet)</th>
<th>LATERAL $L$ (feet)</th>
<th>FAN Min</th>
<th>FAN Max</th>
<th>NAT Min</th>
<th>NAT Max</th>
<th>FAN Min</th>
<th>FAN Max</th>
<th>NAT Min</th>
<th>NAT Max</th>
<th>FAN Min</th>
<th>FAN Max</th>
<th>NAT Min</th>
<th>NAT Max</th>
<th>FAN Min</th>
<th>FAN Max</th>
<th>NAT Min</th>
<th>NAT Max</th>
<th>FAN Min</th>
<th>FAN Max</th>
<th>NAT Min</th>
<th>NAT Max</th>
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<td>6</td>
<td>6</td>
<td>0</td>
<td>698</td>
<td>370</td>
<td>0</td>
<td>897</td>
<td>470</td>
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<td>1121</td>
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<td>575</td>
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<td>855</td>
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<td></td>
</tr>
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<td>50</td>
<td>0</td>
<td>1297</td>
<td>708</td>
<td>0</td>
<td>1730</td>
<td>952</td>
<td>0</td>
<td>2231</td>
<td>1195</td>
<td>0</td>
<td>3441</td>
<td>1825</td>
<td>0</td>
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<td>2550</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>100</td>
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<td>0</td>
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<td>1310</td>
<td>0</td>
<td>3925</td>
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<td>5729</td>
<td>2950</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</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
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
16

15

20

30

50

100

Min

Max

0
2
4
6
0
2
5
8

0
178
242
276
0
168
251
289

2983
1769
1761
1753
3399
2030
2013
2000

1530
1170
1160
1150
1740
1340
1330
1320

0
225
300
341
0
212
311
354

3802
2250
2242
2235
4333
2584
2563
2552

0
2
5
10
15
20
0
2
5
10
15
20
30
0
2
5
10
15
20
30
0
2
5
10
15
20
30
50

0
139
219
273
306
335
0
127
206
259
292
319
369
0
113
191
243
274
300
347
0
95
172
223
252
277
319
415

4948
3097
3071
3029
2988
2948
5725
3696
3666
3617
3570
3523
3433
6711
4554
4520
4464
4409
4356
4253
7914
5834
5797
5737
5678
5619
5505
5289

2520
2000
1978
1940
1910
1880
2920
2380
2350
2300
2250
2200
2130
3440
2840
2813
2767
2721
2675
2631
4050
3500
3475
3434
3392
3351
3267
3100

0
175
270
334
372
404
0
159
252
316
354
384
440
0
141
234
295
330
361
412
0
120
208
268
304
330
378
486

6376
3955
3926
3880
3835
3791
7420
4734
4701
4647
4594
4542
4442
8774
5864
5826
5763
5701
5641
5523
10 485
7591
7548
7478
7409
7341
7209
6956

0
2
5
10
0
2
5
10
15

0
161
243
298
0
147
229
283
318

3742
2256
2238
2209
4423
2719
2696
2659
2623

1925
1480
1461
1430
2270
1770
1748
1712
1675

22

0
202
300
364
0
186
283
346
385

4782
2868
2849
2818
5678
3467
3442
3402
3363

NAT
Max

1960
1480
1475
1470
2220
1700
1685
1670
2450
1890
1871
1840
2900
2260
2235
2193
2150

Min

0
296
390
437
0
278
398
450
0
264
382
459
0
239
355
432
479

FAN

Max

4721
2782
2774
2767
5387
3196
3180
3163
5955
3556
3536
3504
7099
4304
4278
4234
4192

NAT
Max

2430
1850
1835
1820
2750
2110
2090
2070
3050
2340
2318
2280
3620
2800
2777
2739
2700

Min

0
360
469
523
0
336
476
537

FAN

Max

5737
3377
3370
3363
6555
3882
3863
3850

3250
2570
2544
2500
2465
2430
3770
3050
3020
2970
2920
2870
2785
4460
3670
3639
3585
3534
3481
3431
5300
4600
4566
4509
4451
4394
4279
4050

0
220
337
413
459
495
0
199
312
386
431
467
540
0
171
283
355
396
433
494
0
138
245
318
358
387
446
572

7988
4916
4885
4835
4786
4737
9341
5900
5863
5803
5744
5686
5574
11 129
7339
7295
7224
7155
7086
6953
13 454
9577
9528
9447
9367
9289
9136
8841

4060
3200
3174
3130
3090
3050
4750
3810
3783
3739
3695
3650
3565
5635
4630
4597
4542
4511
4479
4421
6700
5800
5769
5717
5665
5613
5509
5300

NAT
Max

0
319
458
546
0
290
426
510
564

7254
4322
4301
4268
8665
5232
5204
5159
5115

0
269
403
489
541
585
0
241
373
456
507
548
635
0
209
336
419
465
506
577
0
169
293
374
418
452
514
659

9785
5983
5950
5896
5844
5792
11 483
7194
7155
7090
7026
6964
6842
13 767
8980
8933
8855
8779
8704
8557
16 817
11 803
11 748
11 658
11 569
11 482
11 310
10 979

Min

0
426
555
618
0
401
562
630

4980
3910
3880
3830
3795
3760
5850
4650
4622
4574
4527
4480
4375
6940
5695
5654
5585
5546
5506
5444
8600
7200
7162
7100
7037
6975
6850
6600

0
321
475
573
631
689
0
285
439
535
590
639
739
0
251
394
491
542
586
672
0
204
341
436
487
523
592
752

3710
2840
2818
2780
4410
3410
3385
3343
3300

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

108

24

2950
2220
2215
2210
3360
2560
2545
2530

T

10

Max

FAN

E-

8

Max

NAT

PR

6

Min

FAN

20

APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR

PR
IN

HEIGHT LATERAL
H
L
(feet)
(feet)

VENT DIAMETER – D (inch)

18

0
378
540
641
0
346
501
599
665

FAN

Max

NAT
Max

6853
4030
4023
4017
7838
4634
4612
4602

3520
2670
2660
2650
4010
3050
3040
3030

11 753
7154
7119
7063
7007
6953
13 848
8617
8574
8505
8437
8370
8239
16 694
10 788
10 737
10 652
10 570
10 488
10 328
20 578
14 264
14 204
14 105
14 007
13 910
13 720
13 354

6000
4700
4662
4600
4575
4550
7060
5600
5552
5471
5391
5310
5225
8430
6860
6818
6749
6710
6670
6603
10 300
8800
8756
8683
8610
8537
8391
8100

8682
5153
5132
5099
10 393
6251
6222
6175
6129

4450
3390
3371
3340
5300
4080
4057
4019
3980

UNIFORM MECHANICAL CODE


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<th>LATERAL L (feet)</th>
<th>FAN</th>
<th>NAT</th>
<th>FAN</th>
<th>NAT</th>
<th>FAN</th>
<th>NAT</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.
### CHIMNEYS AND VENTS

**TABLE 803.1.2(2)**

*TYPE B DOUBLE-WALL GAS VENT [NFPA 54: TABLE 13.1(b)] (continued)*

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**APPLIANCE VENT CONNECTION:** SINGLE-WALL METAL CONNECTOR

**VENT DIAMETER – D (inch)**

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**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.
### Table 803.1.2(3)
Masonry Chimney [NFPA 54: Table 13.1(c)]*

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<table>
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Minimum internal area of chimney (square inches):

- 12
- 19
- 28
- 38
- 50

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.
### Table 803.1.2(3)

**Masonry Chimney (NFPA 54: Table 13.1(c))** (continued)*

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<th>HEIGHT H (feet)</th>
<th>LATERAL L (feet)</th>
<th>FAN TYPE B DOUBLE-WALL CONNECTOR</th>
<th>APPLIANCE VENT CONNECTION: TYPE B DOUBLE-WALL CONNECTOR</th>
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| Minimum internal area of chimney (square inches) | 63 | 78 | 95 | 132 |

**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.

**Note:** Seven times the listed appliance categorized vent area, flue collar area, or draft hood outlet areas.
TABLE 803.1.2(4)
MASSORY CHIMNEY [NFPA 54: TABLE 13.1(d)]*

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SINGLE-WALL METAL CONNECTOR DIAMETER – D (inch)
TO BE USED WITH CHIMNEY AREAS WITHIN THE SIZE LIMITS AT BOTTOM

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APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR

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Minimum internal area of chimney (square inches)

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Maximum internal area of chimney (square inches)

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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)] (continued)*

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#### Single-Wall Metal Connector Diameter – D (inch)

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<th>8</th>
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<th>10</th>
<th>12</th>
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<td></td>
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#### Appliance Input Rating in Thousands of BTU Per Hour

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<th>7</th>
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</tbody>
</table>

* NA: Not applicable.

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

---

Minimum internal area of chimney (square inches): 63

Maximum internal area of chimney (square inches): Seven times the listed appliance categorized vent area, flue collar area, or draft hood outlet areas.

---

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## Table 803.1.2(5)

**SINGLE-WALL METAL PIPE OR TYPE B ASBESTOS-CEMENT VENT [NFPA 54: TABLE 13.1(e)]**

<table>
<thead>
<tr>
<th>Height H (feet)</th>
<th>Lateral L (feet)</th>
<th>Appliance Type: Draft Hood-Equipped</th>
<th>Appliance Vent Connection: Connected Directly to Pipe or Vent</th>
<th>Maximum Appliance Input Rating in Thousands of BTU per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
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<td>3</td>
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<td>141</td>
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<td>260</td>
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<td>6</td>
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<td>242</td>
<td>322</td>
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</table>

*NA: Not applicable.

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 803.1.2(6)
**EXTERIOR MASONRY CHIMNEY** [NFPA 54: TABLE 13.1(f)]

<table>
<thead>
<tr>
<th>NUMBER OF APPLIANCES:</th>
<th>SINGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLIANCE TYPE:</td>
<td>NAT</td>
</tr>
<tr>
<td>APPLIANCE VENT CONNECTION:</td>
<td>TYPE B DOUBLE-WALL CONNECTOR</td>
</tr>
</tbody>
</table>

### MINIMUM ALLOWABLE INPUT RATING OF SPACE-HEATING APPLIANCE IN THOUSANDS OF BTU PER HOUR

<table>
<thead>
<tr>
<th>VENT HEIGHT H (feet)</th>
<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
<th>12</th>
<th>19</th>
<th>28</th>
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<tbody>
<tr>
<td></td>
<td>Local 99% winter design temperature: 37°F or greater</td>
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<tr>
<td></td>
<td>Local 99% winter design temperature: 27°F to 36°F</td>
<td></td>
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<tr>
<td></td>
<td>Local 99% winter design temperature: 17°F to 26°F</td>
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<tr>
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<td>Local 99% winter design temperature: 5°F to 16°F</td>
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<tr>
<td></td>
<td>Local 99% winter design temperature: -10°F to 4°F</td>
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<tr>
<td></td>
<td>Local 99% winter design temperature: -11°F or lower</td>
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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, °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.

PRE-PRINT
### TABLE 803.1.2(7)
#### TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(a)]*

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#### COMMON VENT CAPACITY

<table>
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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.

**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

**Notes:**
- Category I
- Uniform Mechanical Code
- Type B Double-Wall Connector
- Appliance Vent Connection
- Appliance Type
- Number of Appliances
- Appliance Input Rating Limits in Thousands of BTU Per Hour

**Common Vent Diameter**

**Combined Appliance Input Rating in Thousands of BTU per Hour**
### TABLE 803.1.2(7)
#### 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
### TABLE 803.1.2(7)

**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 803.1.2(7)

**TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(a)] (continued)**

**NUMBER OF APPLIANCES:** TWO OR MORE  
**APPLIANCE TYPE:** CATEGORY I  
**APPLIANCE VENT CONNECTION:** TYPE B DOUBLE-WALL CONNECTOR

#### VENT CONNECTOR CAPACITY

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**APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU PER HOUR**

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**COMMON VENT CAPACITY**

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**COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR**

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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(B)

**TYPE B DOUBLE-WALL VENT [NFPA 54: TABLE 13.2(b)]**

| APPLIANCE VENT CONNECTION: | SINGLE-WALL METAL CONNECTOR
|---------------------------|-----------------|

#### NUMBER OF APPLIANCES:
- **TWO OR MORE**

#### APPLIANCE TYPE:
- **CATEGORY I**

#### VENT CONNECTOR CAPACITY

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#### APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU PER HOUR

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#### COMMON VENT CAPACITY

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#### COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU PER HOUR

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For SI units: 1 inch = 25.4 mm, 1 foot = 0.3048 m, 1000 British thermal units per hour = 0.293 kW, 1 square inch = 0.000645 m²

* NA: Not applicable.
### TABLE 803.1.2(8)

**TYPE B DOUBLE-WALL VENT (NFPA 54: TABLE 13.2(b)) (continued)**

| VENT HEIGHT \ Connector Rise (feet) | FAN \ Min | FAN \ Max | NAT \ Min | NAT \ Max | FAN \ Min | FAN \ Max | NAT \ Min | NAT \ Max | FAN \ Min | FAN \ Max | NAT \ Min | NAT \ Max |
|-----------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 6 \ 1                             | 262      | 293      | 325      | 373      | 234      | 281      | 447      | 463      | 286      |
| 8 \ 1                             | 285      | 316      | 352      | 403      | 244      | 292      | 481      | 502      | 299      |
| 10 \ 1                            | 302      | 335      | 372      | 429      | 252      | 302      | 506      | 534      | 308      |
| 15 \ 1                            | 312      | 380      | 397      | 482      | 266      | 339      | 556      | 596      | 324      |
| 20 \ 1                            | 306      | 425      | 390      | 538      | 276      | 358      | 546      | 664      | 336      |
| 30 \ 1                            | 296      | 497      | 378      | 630      | 294      | 429      | 528      | 779      | 358      |
| 50 \ 1                            | 284      | 604      | 364      | 768      | 314      | 467      | 507      | 951      | 384      |
| 100 \ 1                           | 269      | 774      | 345      | 993      | 321      | 476      | 476      | 1236     | 393      |

### 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 803.1.2(9)**
MASTERY CHIMNEY [NFPA 54: TABLE 13.2(c)]*

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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 803.1.2(9)

**MASONRY CHIMNEY** [NFPA 54: TABLE 13.2(c)] (continued)*

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#### APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU PER HOUR

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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.
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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(10)
MASSONRY CHIMNEY [NFPA 54: TABLE 13.2(d)] (continued)*

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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(11)
SINGLE-WALL METAL PIPE OR TYPE B ASBESTOS-CEMENT VENT [NFPA 54: TABLE 13.2(e)]*

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<tr>
<td>APPLIANCE VENT CONNECTION: DIRECT TO PIPE OR VENT</td>
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#### VENT CONNECTOR DIAMETER – \( D \) (inch)

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<th>CONNECTOR RISE ( R ) (feet)</th>
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<th>5</th>
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#### COMMON VENT DIAMETER – \( D \) (inch)

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<td>395</td>
<td>560</td>
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<td>71</td>
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<td>550</td>
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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 803.1.2(12)
**EXTERIOR MASONRY CHIMNEY [NFPA 54: TABLE 13.2(f)]**

<table>
<thead>
<tr>
<th>VENT HEIGHT $H$ (feet)</th>
<th>12</th>
<th>19</th>
<th>28</th>
<th>38</th>
<th>50</th>
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<th>78</th>
<th>113</th>
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<tbody>
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<td>53</td>
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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(13)
**EXTERIOR MASONRY CHIMNEY [NFPA 54: TABLE 13.2(g)]**

<table>
<thead>
<tr>
<th>NUMBER OF APPLIANCES: TWO OR MORE</th>
<th>APPLIANCE TYPE: NAT + NAT</th>
<th>APPLIANCE VENT CONNECTION: TYPE B DOUBLE-WALL CONNECTOR</th>
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**MINIMUM ALLOWABLE INPUT RATING OF SPACE-HEATING APPLIANCE IN THOUSANDS OF BTU PER HOUR**

<table>
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<tr>
<th>VENT HEIGHT $H$ (feet)</th>
<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
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<th>28</th>
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<th>78</th>
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<tbody>
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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, °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.
### CHIMNEYS AND VENTS

#### TABLE 803.1.2(14)
**EXTERIOR MASONRY CHIMNEY [NFPA 54: TABLE 13.2(h)]**

<table>
<thead>
<tr>
<th>VENT HEIGHT $H$ (feet)</th>
<th>12</th>
<th>19</th>
<th>28</th>
<th>38</th>
<th>50</th>
<th>63</th>
<th>78</th>
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<td>384</td>
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</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

* NA: Not applicable.
TABLE 803.1.2(15)

EXTERIOR MASONRY CHIMNEY (NFPA 54: TABLE 13.2(i))

<table>
<thead>
<tr>
<th>VENT HEIGHT (Feet)</th>
<th>INTERNAL AREA OF CHIMNEY (square inches)</th>
<th>MINIMUM ALLOWABLE INPUT RATING OF SPACE-HEATING APPLIANCE IN THOUSANDS OF BTU PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>NA</td>
</tr>
<tr>
<td>100</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Local 99% winter design temperature: 37°F or greater

Local 99% winter design temperature: 27°F to 36°F

Local 99% winter design temperature: 17°F to 26°F

Local 99% winter design temperature: 5°F to 16°F

Local 99% winter design temperature: -10°F to 4°F

Local 99% winter design temperature: -11°F or lower

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 = 0.000654 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 Gas 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. Unlisted appliances shall be installed as specified in this part as applicable to the equipment. For additional information concerning particular appliances and accessories, including industrial types, reference can be made to the standards listed in Chapter 17. [NFPA 54:10.1.1]

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]

902.54 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.

902.65 Building Structural Members. Appliances and equipment shall be furnished either with load-distributing bases or with an approved number of supports to prevent damage to either the building structure or the appliance and the equipment. [NFPA 54:9.1.8.1]

902.65.1 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 capable to carry the additional loads. 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]

902.72 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 accordance with Section 305.1, Section 905.87, or and Section 905.98 shall be considered to be in accordance with the intent of this provision. [NFPA 54:9.1.9]

902.76.1 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 equipment 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 installed in accordance with the appliance manufacturer’s installation instructions. [NFPA 54:9.1.6.2]

902.76 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.

902.98 Combination of Appliances and Equipment. A combination of appliances, equipment, attachments, or devices used together in a manner shall be in accordance with the standards that apply to the individual appliance and equipment. [NFPA 54:9.1.21]
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 conditioners shall comply with Section 903.2.1 through Section 903.2.45.

903.2.1 Independent Gas Piping. Gas piping serving heating appliances shall be permitted to serve cooling appliances where heating and cooling appliances are not capable of being operated simultaneously. (See Section 1308.4) [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. [NFPA 54:10.2.3(1)]

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, rear and in accordance with the manufacturer’s installation instructions. [NFPA 54:10.2.3(2)]

3. Air-conditioning appliances (listed and unlisted) installed in rooms that are large in comparison with the size of the appliance shall be permitted to be installed with reduced clearances to combustible material provided the combustible material or appliance is protected as described in Table 303.10.1(2), see Footnote 2. [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 from the plaster or other noncombustible finish to the clearance specified is not more than 2 inches (51 mm). [NFPA 54:10.2.3(5)]

5. Listed air-conditioning appliances shall have clearance from supply ducts, within 3 feet (914 mm) of the furnace plenum, of not less than that specified from the furnace plenum. No clearance is necessary beyond this distance. [NFPA 54:10.2.3(6)]

903.2.43 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]

903.2.64 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 installation instructions. Where a furnace plenum is not supplied with the appliance, fabrication and installation instructions provided by the manufacturer shall be followed. The method of connecting supply and return ducts shall facilitate circulation of air. Where the air conditioner is installed within a closet, the air circulated by the appliance shall be handled by ducts that are sealed to the casing of the appliance and that separate the circulating air from the combustion and ventilation air. [NFPA 54:10.2.5]

903.2.6 Refrigeration Coils. See Section 904.8 and Section 904.9. [NFPA 54:10.2.6]

903.2.75 Switches in Electrical Supply Line. Means for interrupting the electrical supply to the air-conditioning appliance and to its associated cooling tower (where 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 cooling tower. [NFPA 54:10.2.7]

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. [NFPA 54:10.3.1(2)]

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 boilers and furnaces shall be provided with clearances in accordance with the following:
(1) 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. [NFPA 54:10.3.2.1]

(2) 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 and such reduction is allowed by the manufacturer’s installation instructions. [NFPA 54:10.3.2.2]

(3) Listed and unlisted 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 in accordance with Table 903.10.1. [NFPA 54:10.3.2.4]

(4) Front clearance shall be sufficient for servicing the burner and the furnace or boiler. [NFPA 54:10.3.2.5]

(5) 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 54:10.3.2.6]

(6) The clearance to these appliances shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing. (See Section 304.0, Section 701.0, and Section 802.12.6) [NFPA 54:10.3.2.7]

(7) 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 is not required beyond the 3 feet (914 mm) distance. [NFPA 54:10.3.2.8]

(8) Supply air ducts connecting to unplisted 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 is not required beyond the 6 feet (1829 mm) distance. [NFPA 54:10.3.2.9]

(9) Central heating furnaces other than those listed in Section 904.2(23) or Section 904.2(84) 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 54:10.3.2.449]

904.3 Assembly and Installation. A central-heating boiler or furnace shall be installed in accordance with the manufacturer’s installation instructions. It shall be installed on a floor of noncombustible construction with noncombustible flooring, and surface finish, and with no combustible material against the underside thereof; or 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 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 extend to a depth of 6

| TABLE 904.2 CLEARANCES TO COMBUSTIBLE MATERIAL FOR UNLISTED FURNACES, BOILERS, AND AIR CONDITIONERS* |
|-----------------------------------------------|-------------------------------------------------|------------------------------------------------|-----------------|-----------------|------------------|
| APPLIANCE                                      | ABOVE AND SIDES OF FURNACE PLENUM | TOP OF BOILER | JACKET SIDES AND BAROMETRIC DRAFT REGULATOR | SINGLE-WALL VENT CONNECTOR |
| I Automatically fired, forced air or gravity system, equipped with temperature limit control that is not capable of being set to exceed 250°F | 6 | – | 6 | 18 | 6 | 18 |
| II Automatically fired heating boilers – steam boilers operating not exceeding 15 pounds-force per square inch (psi) and hot water boilers operating at 250°F or less | 6 | 6 | 6 | 18 | 18 | 18 |
| III Central heating boilers and furnaces, other than in I or II | 18 | 18 | 18 | 18 | 18 | 18 |
| IV Air-conditioning appliance | 18 | 18 | 18 | 18 | 18 | 18 |

For SI units: 1 inch = 25.4 mm, °C = (°F-32)/1.8, 1 pound-force per square inch = 6.8947 kPa

* See Section 904.2(23) and 903.0 for additional requirements for air-conditioning appliances and Section 904.1 for additional requirements for central heating boilers and furnaces.
Furnace Plenums and Air Ducts. Furnace plenums and air ducts shall be installed in accordance with the following:

1. Furnace plenums and air ducts shall be installed in accordance with NFPA 90A.

2. A furnace plenum supplied as a part of a furnace shall be installed in accordance with the manufacturer’s installation instructions.

3. Where a furnace plenum is not supplied with the furnace, fabrication, and installation shall be in accordance with the manufacturer’s installation instructions. The method of connecting supply and return ducts shall facilitate circulation of air.

4. 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 be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace.

5. A refrigeration coil at the discharge near the floor.

6. The entire discharge piping shall be not less than the same size as the relief valve discharge piping.

7. Discharge piping shall not contain a threaded end connection at its termination point.

904.6 Furnace Plenums and Air Ducts. Furnace plenums and air ducts shall be installed in accordance with the following:

1. Furnace plenums and air ducts shall be installed in accordance with NFPA 90A.

2. A furnace plenum supplied as a part of a furnace shall be installed in accordance with the manufacturer’s installation instructions.

3. Where a furnace plenum is not supplied with the furnace, fabrication, and installation shall be in accordance with the manufacturer’s installation instructions. The method of connecting supply and return ducts shall facilitate circulation of air.

4. 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 be handled by a duct(s) sealed to the furnace casing and terminating outside the space containing the furnace.

5. 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 resistance imposed by the duct system and refrigeration coil at the air flow rate for heating or cooling, whichever is greater.

6. 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.

7. 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.

8. Means shall be provided for disposal of condensate and to prevent dripping of condensate on the heating element.

904.7 Cooling Units used with Heating Boilers. Cooling coils used with heating boilers shall be installed in accordance with the following:

1. 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 valves to prevent the chilled medium from entering the heating boiler.

2. Where hot-water-heating boilers are connected to heating coils located in air-handling units where they are capable of being 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.

904.8 Refrigeration Coils. Refrigeration coils shall be installed in parallel with or on the discharge capacity and shall comply 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.

904.9 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 discharge capacity and shall comply 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.

904.10 Refrigeration Coils. 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.

904.11 Means shall be provided for disposal of condensate and to prevent dripping of condensate on the heating element.

905.0 Duct Furnaces. The installation of duct furnaces shall comply with the following requirements:

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. In no case shall the clearance be such as to interfere with combustion air and accessibility. (See Section 304.0 and Section 701.0)

(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. Combustible floors under unlisted duct furnaces shall be protected in an approved manner. [NFPA 54:10.10.1]

905.21 Installation of Duct Furnaces. Duct furnaces shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.10.2]

905.32 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]

905.43 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]

905.54 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]

905.65 Duct Furnaces Used with Refrigeration Systems. Duct furnaces used with refrigeration systems shall be installed in accordance with the following:

(1) 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 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]

(2) Duct furnaces used in conjunction with cooling equipment 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 tight to prevent a 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]

(3) 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]

(4) 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 ion-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 are considered as refrigeration systems. [NFPA 54:10.10.6.4]

905.76 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 905.87 and Section 905.98. [NFPA 54:10.10.7]

905.87 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]

905.87.1 Repair Garages. Appliances installed in repair garages shall be installed in a detached building or room, separated from repair areas by walls, partitions, floors, or floor-ceiling assemblies that are constructed so as to prohibit the transmission of vapors and having a fire resistance rating of not less than 1 hour, and that have no openings in the wall separating the repair area within 8 feet (2438 mm) of the floor. Wall penetrations shall be firestopped. Air for combustion purposes shall be obtained from outside the building. The heating room shall not be used for the storage of combustible materials.

Exceptions:

(1) Overhead heaters where installed not less than 8 feet (2438 mm) above the floor shall be permitted.

(2) Heating appliances for vehicle repair areas where there is no dispensing or transferring of Class I or Class II flammable or combustible liquids or liquefied petroleum gas shall be installed in accordance with NFPA 30A. [NFPA 54:9.1.11.2]

905.88 Installation in Aircraft Hangars. Heaters in aircraft hangars shall be installed in accordance with NFPA 409. [NFPA 54:9.1.12]

905.9 Electric Duct Heaters. Electric duct heaters installed within an air duct shall be listed for such use 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.

905.9.1 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.
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 in 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. [NFPA 54:10.11.1]

906.21 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]

906.22 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.11.3]

906.43 Placement. The following provisions apply to furnaces that serve one story:

1. Floor furnaces shall not be installed in the floor of a doorway, stairway landing, aisle, or passageway of an enclosure, public or private, or in an exitway from such room or space.

2. 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 not less than 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 not less than 6 inches (152 mm) from a wall. Wall-register models shall not be placed closer than 6 inches (152 mm) to a corner.

3. The furnace shall be placed so that a door, drapery, or similar object is not closer than 12 inches (305 mm) to a portion of the register of the furnace. [NFPA 54:10.11.4]

906.54 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]

906.65 Support. Means shall be provided to support the furnace where the floor register is removed. [NFPA 54:10.11.6]

906.76 Clearance. The lowest portion of the floor furnace shall have not less than a 6 inch (152 mm) clearance from the general ground level. A reduced clearance to not less than 2 inches (51 mm) is 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 the sides except the control side, that which has an 18 inch (457 mm) clearance. [NFPA 54:10.11.7]

906.87 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]

906.98 Seepage Pan. Where the excavation exceeds 12 inches (305 mm) in depth or water seepage is capable of collecting, a watertight copper pan, concrete pit, or other approved material shall be used, unless approved 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 not less than 4 inches (102 mm) above the ground level with not less than 6 inches (152 mm) clearance on all sides, except the control side, which shall have not less than 18 inches (457 mm) clearance. [NFPA 54:10.11.9]

906.109 Wind Protection. Floor furnaces shall be protected, where necessary, against severe wind conditions. [NFPA 54:10.11.10]

906.140 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, the furnace clearances of not less than 6 inches (152 mm) to the sides and bottom, and with the enclosure constructed of Portland cement plaster or metal lath or other noncombustible material. [NFPA 54:10.11.11]

906.121 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]

908.5 908.12 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. Wall furnaces shall be installed in accordance with the following:

(1) 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. [NFPA 54:10.27.1.1]

(2) Unlisted wall furnaces shall not be installed in or attached to combustible material. [NFPA 54:10.27.1.2]

(3) Vented wall furnaces connected to a Type B-W gas vent system listed for a single story shall be installed 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 shall be permitted to be an integral part of the vented wall furnace. 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. (See Figure 907.1 for Type B-W gas vent installation) [NFPA 54:10.27.1.3]

(4) Direct-vent wall furnaces shall be installed with the vent-air intake terminal in the outside atmosphere. 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 instructions. [NFPA 54:10.27.1.4]

(5) 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 in this code. [NFPA 54:10.27.1.5]

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 54:10.27.2]

907.3 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.27.3]

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 Furnaces.

908.2 Oil-Fired Boilers. Oil-fired boiler assemblies shall comply with UL 726 and installed in accordance with the manufacturer’s installation instructions.

909.0 908.0 Clothes Dryers.

909.1 908.1 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.

909.2 908.2 Gas-Fired Clothes Dryers. Gas-fired clothes dryers shall comply with Section 909.2.1 through Section 909.2.3.

909.2.1 Clearance. The installation of clothes dryers shall comply with the following requirements:

(1) Listed Type I 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. 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.

(2) 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. [NFPA 54:10.4.1]

909.2.2 908.2.1 Exhausting to the Outdoors. Type 1 and Type 2 clothes dryers shall be exhausted to the outside air in accordance with Section 504.3. [NFPA 54:10.4.2]

909.2.2 908.2.2 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 504.3.3.4. [NFPA 54:10.4.6]

910.0 909.0 Conversion Burners.

910.1 909.1 General. Installation of conversion burners shall comply with CSA Z21.8. [NFPA 54:10.5]

934.0 910.0 Burner Assemblies.

934.1 910.1 Oil Burners. Oil burners shall comply with UL 296 and installed in accordance with the manufacturer’s installation instructions.

934.2 910.2 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 in a vented fireplace having a working chimney flue and constructed of noncombustible materials. These appliances shall not be thermostatically controlled:

(1) A listed decorative appliance for installation in a vented fireplace shall be installed in accordance with its listing and the manufacturer’s installation instructions.

(2) 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]

(3) 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]

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.

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>8</th>
<th>13</th>
<th>20</th>
<th>29</th>
<th>39</th>
<th>51</th>
<th>64</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MINIMUM PERMANENT FREE OPENING (square inches)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>7800</td>
<td>14 000</td>
<td>23 200</td>
<td>34 000</td>
<td>46 400</td>
<td>62 400</td>
<td>80 000</td>
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<tr>
<td>8</td>
<td>8400</td>
<td>15 200</td>
<td>25 200</td>
<td>37 000</td>
<td>50 400</td>
<td>68 000</td>
<td>86 000</td>
</tr>
<tr>
<td>10</td>
<td>9000</td>
<td>16 800</td>
<td>27 600</td>
<td>40 400</td>
<td>55 800</td>
<td>74 400</td>
<td>96 400</td>
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<tr>
<td>15</td>
<td>9800</td>
<td>18 200</td>
<td>30 200</td>
<td>44 600</td>
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<td>84 000</td>
<td>108 800</td>
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<td>20 200</td>
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<tr>
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<td>21 600</td>
<td>36 600</td>
<td>55 200</td>
<td>76 800</td>
<td>105 800</td>
<td>138 600</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 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.
914.2 Prohibited Installations. Non-recirculating direct gas-fired industrial air heaters shall not be installed in the following conditions:

(1) Non-recirculating direct gas-fired industrial air heaters shall not serve an area containing sleeping quarters. [NFPA 54:10.8.2.1]

(2) Non-recirculating direct gas-fired industrial air heaters shall not recirculate room air. [NFPA 54:10.8.2.2]

914.3 Installation. Installation of direct gas-fired industrial air heaters shall comply with the following requirements:

(1) Non-recirculating direct gas-fired industrial air heaters shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.8.3.1]

(2) Non-recirculating direct gas-fired industrial air heaters shall be installed in industrial or commercial occupancies. [NFPA 54:10.8.3.2]

(3) Non-recirculating direct gas-fired industrial air heaters shall be permitted to provide fresh air ventilation. [NFPA 54:10.8.3.3]

(4) Non-recirculating direct gas-fired industrial air heaters shall be provided with an access for removal of burners; 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 54:10.8.4]

914.5 Air Supply. Air to the nonrecirculating direct gas-fired industrial air heater shall be ducted directly from outdoors. Where outside-air dampers or closing louvers are used, they shall be verified to be in the open position prior to main burner operation. [NFPA 54:10.8.5]

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 54:10.8.6]

914.7 Relief Openings. The design of the installation shall include approved provisions to permit the nonrecirculating 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:

(1) The structure’s designed infiltration rate and the size of relief opening(s) shall be determined by approved engineering methods.

(2) 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]

914.8 Purging. Inlet ducting, where used, shall be purged with not less than 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 designed and certified to be in accordance with CSA Z83.18. [NFPA 54:10.9.1]

915.21 Prohibited Installations. Recirculating direct gas-fired industrial air heaters shall not be installed in the following conditions:

1. Recirculating direct gas-fired industrial air heaters shall not serve an area containing sleeping quarters. [NFPA 54:10.9.2.1]

2. Where outdoor air dampers or closing louvers are used, they shall be proved to be in their open position prior to main burner operation. [NFPA 54:10.9.7.1]

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. [NFPA 54:10.9.3]

2. Recirculating direct gas-fired industrial air heaters shall be installed in industrial or commercial occupancies. [NFPA 54:10.9.3]

915.4 Clearances 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]

915.4 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 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]:

1. 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]

2. Louver or counterbalanced gravity relief openings shall be permitted. Where motorized 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]

915.8 Purging. Inlet ducting, where used, shall be purged with not less than 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 in accordance with Section 902.21.

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 in accordance with Section 902.21. [NFPA 54:10.23.1]

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 54:10.23.3]

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 so on, 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. 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 arranged 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. Room heaters other than those of the circulating type described in Section 916.2.43 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. [NFPA 54:10.23.4]

916.2.43 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 54:10.23.5]

916.3 Solid-Fuel-Type Room Heaters. Solid-fuel-type room heaters shall comply with UL 1482.

917.0 Unit Heaters.

917.1 Support. Suspended-type unit heaters shall be supported with due consideration given to their weight and vibration characteristics. Hangers and brackets shall be of non-combustible material. [NFPA 54:10.26.1]

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 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. [NFPA 54:10.26.2.1]

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 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. [NFPA 54:10.26.2.2]

917.32 Combustion and Circulating Air. Combustion and circulating air shall be provided in accordance with Section 701.0. [NFPA 54:10.26.3]

917.43 Ductwork. A unit heater shall not be attached to a warm air duct system unless listed and marked for such installation. [NFPA 54:10.26.4]

917.54 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 905.87 and Section 905.88. [NFPA 54:10.26.5]

917.65 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, gas-fired 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 2 inches (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. [NFPA 54:10.12.1]

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 18 inches (457 mm) above cooking tops and at the front of the appliance. Clearances for unlisted appliances installed in partially enclosed areas such as alcoves shall not be reduced. Where clearances for unlisted appliances installed in rooms that are not partially enclosed are reduced, the combustible material or the appliance shall be protected as described in Table 303.10.1. [NFPA 54:10.12.2]
918.31 Mounting on Combustible Floor.

(4) 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.

(2) Floor-mounted food service appliances that are not listed for mounting on a combustible floor shall be mounted in accordance with Section 918.42 or be mounted in accordance with one of the following:

(a) 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 an 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 there is not less than one sheet metal baffle between the burner and the floor.

(b) 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 \( \frac{3}{8} \) 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.

(c) 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.

(d) Where the appliance does not have legs not less than 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 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 sheet metal not less than \( \frac{3}{8} \) of an inch (4.8 mm) in thickness. [NFPA 54:10.12.3.2]

918.42 Installation on Noncombustible Floor.

Listed floor-mounted 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. Such construction shall extend not less than 12 inches (305 mm) beyond the appliance on all sides. [NFPA 54:10.12.4]

918.53 Combustible Material Adjacent to Cooking Top. A portion of combustible material adjacent to a cooking top section of a food service range, even though listed for close-to-wall installation, that is not shielded from the wall by a high shelf, warming closet, and so on, shall be protected as specified in Section 918.2 Table 303.10.1 for a distance of not less than 2 feet (610 mm) above the surface of the cooking top. [NFPA 54:10.12.5]

918.64 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]

918.75 Level Installation.

Floor-mounted food service appliances shall be installed level on a firm foundation. [NFPA 54:10.12.7]

918.86 Ventilation.

Means shall be provided to ventilate the space in which food service appliance is installed to permit 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 1.2 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 instructions. [NFPA 54:10.13.2]

919.32 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]

919.43 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
Gas-Fired Household Cooking Appliances.

Section 921.4.2.1 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 24 inches (610 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. [NFPA 54:10.15.1.1]

921.4.23.1 Vertical Clearance Above Cooking Top. Household 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: [NFPA 54:10.15.1.2]

1. The underside of the combustible material or metal cabinet above the cooking top is protected with not less than 1/4 of an inch (6.4 mm) insulating millboard covered with sheet metal not less than 0.0122 of an inch (0.3099 mm) thick. [NFPA 54:10.15.1.2(1)]

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 1/4 of an inch (6.4 mm) between the hood and the underside of the combustible material or metal cabinet, and the hood is as wide as the appliance and is centered over the appliance. [NFPA 54:10.15.1.2(2)]

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. [NFPA 54:10.15.1.2] Microwave ovens shall comply with UL 923.

921.54 Built-In Units. Built-in units shall be installed in accordance with Section 921.54.1 through and Section 921.54.2.

921.5.1 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. [NFPA 54:10.15.2.1]

921.5.2 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 1/4 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 1/4 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. [NFPA 54:10.15.2.3]

921.5.34.1 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]

921.6.4.2 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]

922.0 Cooking Appliances.

922.1 Commercial Electric Ranges. Commercial electric ranges shall comply with UL 197 and installed in accordance with the manufacturer’s installation instructions.

922.2 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.

922.3 Oil-Burning Ranges. Oil-burning ranges shall comply with UL 896 and installed in accordance with the manufacturer’s installation instructions.

923.0 Open-Top Broiler Units.

923.1 Listed Units. Listed open-top broiler units shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.19.1]

923.2 Unlisted Units. Unlisted open-top broiler units shall be installed in accordance with the manufacturer’s installation instructions but shall not be installed in combustible material. [NFPA 54:10.19.2]

923.3 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 1/4 of an inch (6.4 mm) between the hood and the underside of combustible material or metal cabinets. A clearance of not less than 24 inches (610 mm) shall be maintained between the cooking top and the combustible material or metal cabinet, and the hood shall be 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 need not be provided with a ventilating hood where installed in accordance with Section 921.4.23.1(1). [NFPA 54:10.19.3]

923.4 Commercial Units. Commercial open-top broiler units shall be provided with ventilation in accordance with Chapter 5. [NFPA 54:10.19.4]

924.0 Outdoor Cooking Appliances.

924.1 Listed Units. Listed outdoor cooking appliances shall be installed in accordance with their listing and the manufacturer’s installation instructions. [NFPA 54:10.20.1]

924.21 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 54:10.20.2]

925.0 Illuminating Appliances.

925.21 Clearances for Unlisted Appliances. Unlisted illuminating appliances shall be installed with clearances in accordance with the following:

(1) Unlisted enclosed illuminating appliances installed outdoors shall be installed with clearances from combustible material of not less than 12 inches (305 mm). [NFPA 54:10.16.2.1(1)]

(2) Unlisted enclosed illuminating appliances installed indoors shall be installed with clearances from combustible material of not less than 18 inches (457 mm). [NFPA 54:10.16.2.1(2)]

91.2.1 925.2 Open-Flame Type. Open-flame illuminating appliances shall be installed with clearances in accordance with the following:

(1) Unlisted open-flame illuminating appliances installed outdoors shall have clearances from combustible material not less than that specified in Table 925.2. The distance from ground level to the base of the burner shall be not less than 7 feet (2134 mm) where installed within 2 feet (610 mm) from walkways. Lesser clearances shall be permitted to be used where acceptable to the Authority Having Jurisdiction. [NFPA 54:10.16.2.2(1)]

(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 in accordance with Table 925.2. [NFPA 54:10.16.2.2(2)]

(3) Appliances designed for flame heights in excess of 30 inches (762 mm) shall be permitted to be installed where acceptable to the Authority Having Jurisdiction. Such
appliances shall be equipped with a safety shutoff device or automatic ignition. [NFPA 54:10.16.2.2(3)]

(4) Unlisted open-flame illuminating appliances installed indoors shall have clearances from combustible material acceptable to the Authority Having Jurisdiction. [NFPA 54:10.16.2.2(4)]

<table>
<thead>
<tr>
<th>TABLE 925.2</th>
<th>CLEARANCES FOR UNLISTED OUTDOOR OPEN-FLAME ILLUMINATING APPLIANCES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLAME HEIGHT ABOVE BURNER HEAD (inches)</strong></td>
<td><strong>MINIMUM CLEARANCE FROM COMBUSTIBLE MATERIAL (feet)</strong></td>
</tr>
<tr>
<td></td>
<td>HORIZONTAL</td>
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<tr>
<td>12</td>
<td>2</td>
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<td>18</td>
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<td>24</td>
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<tr>
<td>30</td>
<td>4</td>
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</tbody>
</table>

For SI units: 1 inch = 25.4 mm, 1 foot = 304.8 mm
* Measured from the nearest portion of the burner head.

925.3 Mounting on Buildings. Illuminating appliances designed for wall or ceiling mounting shall be securely attached to structures in such a manner that they are not dependent on the gas piping for support. [NFPA 54:10.16.3]

925.4 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 exceeding 3 feet (914 mm) in height shall be not less than 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 ¾ of an inch (19.1 mm) Schedule 40 steel pipe. Drain openings shall be provided near the base of posts where there is a possibility of water collecting inside them. [NFPA 54:10.16.4]

925.5 Gas Appliance Pressure Regulators. Where a gas 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 54:10.16.5]

926.0 Incinerators and Crematories.
926.1 Field Constructed Commercial-Industrial Incinerators. Field constructed commercial-industrial incinerators shall be constructed and installed in accordance with NFPA 82.

926.2 Factory-Built Commercial Incinerators and Crematories. Factory-built commercial incinerators and crematories shall comply with UL 2790 and installed in accordance with the manufacturer’s installation instructions.

926.3 Residential Incinerators. Residential incinerators shall comply with UL 791 and installed in accordance with the manufacturer’s installation instructions.

927.0 Infrared Heaters.
927.1 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 54:10.18.1]

927.2 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 NFPA 82.

927.3 Clearance. The installation of infrared heaters shall comply with the following clearance requirements:

(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) One connector shall be used per appliance. [NFPA 54:9.6.1.3]

927.4 Combustion and Ventilation Air. Combustion and ventilation air for infrared heaters shall be provided in accordance with the following:

(1) Where unveinted infrared heaters are used, natural or mechanical means shall be provided to supply and exhaust not less than 4 cubic feet per minute per 1000 British thermal units per hour [(ft³/min)/(Btu/h)] [0.4 (m³/min)/kW] input of installed heaters. [NFPA 54:10.18.3.1]
(2) Exhaust openings for removing flue products shall be above the level of the heaters. [NFPA 54:10.18.3.2]

927.64 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 905.87 and Section 905.98. [NFPA 54:10.18.4]

928.0 Pool Heaters.
928.1 Location. A pool heater shall be located or protected so as to minimize accidental contact of hot surfaces by persons. [NFPA 54:10.21.1]

928.2 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. [NFPA 54:10.21.2]

928.3 Temperature or Pressure-Limiting Devices.
Pool heaters shall be provided with temperature or pressure-limiting devices in accordance with the following:

1. An unlisted pool heater shall be provided with overtemperature protection or overtemperature and overpressure protection by means of an approved device(s). [NFPA 54:10.21.3.1]

2. Where a pool heater is provided with over-temperature protection and is installed with a device in the discharge line of the heater that is capable of restricting 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 54:10.21.3.2]

928.4 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 54:10.21.4]

928.5 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. (See Section 802.2.4, Section 802.2.5, Section 802.3.3, and Section 802.8) [NFPA 54:10.21.5]

929.0 Refrigerators.
929.1 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, not less than 2 inches (51 mm) shall be provided between the back of the refrigerator and the wall and not less than 12 inches (305 mm) above the top. [NFPA 54:10.22.1]

929.2 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 installation instructions. [NFPA 54:10.22.2]

930.0 Gas-Fired Toilets.
930.1 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 afford ready accessibility for use, cleanout, and necessary servicing. [NFPA 54:10.25.1]

930.21 Installation on Combustible Floors.
Listed gas-fired toilets installed on combustible floors shall be listed for such installation. [NFPA 54:10.25.2]

930.32 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 54:10.25.3]

931.0 Appliances for Installation in Manufactured Housing.
931.1 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 54:10.30]

932.0 Small Ceramic Kilns.
932.1 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.

932.2 Installation.
Kilns shall be installed in accordance with the manufacturer’s installation instructions and the provisions of this code.

932.3 Fuel-Gas Controls.
Fuel-gas controls shall comply with Section 306.0 and Section 1311.1.4. Standing pilots shall not be used with gas-fired kilns.

932.4 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.

932.5 Installations Inside Buildings.
In addition to other requirements specified in this section, interior installations shall comply with the requirements of Section 932.5.1 through Section 932.5.5.

932.5.1 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 electrical control side of a kiln be reduced to less than 30 inches (762 mm).

932.5.2 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 U.S. 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.

932.5.3 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.

932.5.4 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.

932.5.5 Hood and Duct Clearances. 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.

932.6 Exterior Installations. Kilns shall be installed with minimum clearances as specified in Section 932.5.1. Whenever 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 932.5.2, Section 932.5.3, and Section 932.5.5.

933.0 Outdoor Open Flame Decorative Appliances.

933.1 General. Permanently fixed in place outdoor open flame decorative appliances shall be installed in accordance with Section 933.1.1 through Section 933.1.3. [NFPA 54:10.32]

933.1.1 Listed Units. Listed outdoor open flame decorative appliances shall be installed in accordance with the manufacturer’s installation instructions. [NFPA 54:10.32.1]

933.1.2 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 54:10.32.2]

933.1.3 Connection to the Piping System. The connection to the gas piping system shall comply with Section 1312.1(1), Section 1312.1(2), Section 1312.1(3), or Section 1312.1(5). [NFPA 54:10.32.3]

935.0 934.0 Evaporative Cooling Systems.

935.1 934.1 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 935.2 through Section 934.4.3. Evaporative cooling systems shall be provided with outside air as specified for cooling systems in Section 403.0.

935.2 934.2 Location. Evaporative cooling systems shall be installed so as to minimize the probability of damage from an external source.

935.3 934.3 Access, Inspection, and Repair. Evaporative coolers shall be accessible for inspection, service, and replacement without removing permanent construction.

935.4 934.4 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.

935.4.1 934.4.1 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.

935.4.2 934.4.2 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.

935.4.3 934.4.3 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.

936.0 935.0 Refrigeration Appliances.

936.1 935.1 Self-Contained Refrigerators and Freezers. Factory-built commercial refrigerators and freezers shall comply with UL 471 and installed in accordance with the manufacturer’s installation instructions.

936.2 935.2 Unit Coolers. Factory-built unit coolers for use in refrigerators, freezers, refrigerated warehouses, and walk-in coolers shall comply with UL 412 and installed in accordance with the manufacturer’s installation instructions.

936.3 935.3 Self-Contained Mechanical Refrigeration Systems. Self-contained mechanical refrigeration systems for use in walk-in coolers shall comply with UL 427 and installed in accordance with the manufacturer’s installation instructions.
937.0 936.0 Ductless Mini-Split Systems Installation.
937.1 936.1 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.

938.0 937.0 Air Filter Appliances.
938.1 937.1 Electrostatic Air Cleaners. Electrostatic air cleaners shall comply with UL 867 and installed in accordance with the manufacturer’s installation instructions.

938.2 937.2 High-Efficiency Particulate Air Filter Units. High-efficiency particulate air filter units for use in industrial and laboratory exhaust and ventilation systems shall comply with UL 586 and be installed in accordance with the manufacturer’s installation instructions.

939.0 938.0 Gaseous Hydrogen Systems.
939.1 938.1 General. Gaseous hydrogen systems shall be installed in accordance with NFPA 2.

940.0 939.0 Compressed Natural Gas (CNG) Vehicular Fuel Systems.
940.1 939.1 General. The installation of compressed natural gas (CNG) fueling (dispensing) systems shall comply with NFPA 52. [NFPA 54:10.29]
1001.0 General.

1001.1 Applicability. The requirements of this chapter shall apply to the construction, installation, operation, repair, and alteration of all 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 standards:
(1) ASME BPVC Section I
(2) ASME BPVC Section IV
(3) NFPA 85
(4) ASME CSD-1

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 Boilers. Solid-fuel boilers shall comply with UL 2523 and 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 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.

Except as otherwise specified, gas-fired boilers exceeding 400,000 Btu/h (117 kW) input shall comply with nationally recognized standards approved by the Authority Having Jurisdiction.

The Authority Having Jurisdiction shall have the authority to approve solid-fuel-fired boilers that comply with the safety requirements for automatic gas- or oil-fired boilers.

1003.3 Gauges. A steam boiler shall be provided with a pressure gauge and a water level glass. A water boiler shall be provided with a pressure gauge and a temperature gauge. Automatic boilers shall be equipped with the following gauges:

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 Systems with Open Type Expansion Tanks. Open type expansion tanks shall be located not less than 3 feet (914 mm) above the highest point of the system. Such tanks shall be sized based on the capacity of the system. An overflow with a diameter of not less than one-half the size of the 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 or above more than 30 pounds-force per square inch (psi) (207 kPa) shall comply with, be constructed in accordance with nationally recognized standards, ASME BPVC Section VIII, and the Authority Having Jurisdiction. Provisions shall be made for draining the tank without emptying the system, except for pressurized tanks.

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 of the closed-type for a forced-type hot water system expansion tank shall be in accordance with Table 1004.4(1) and Table 1004.4(2), or from the following formula: Equation 1004.4. Equation 1004.4 shall not be used for diaphragm-type expansion tanks.

\[
V_t = \frac{0.00041 t - 0.0466}{P_f - P_o} V_s
\]

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 H\(_2\)O absolute
- \( P_f \) = Fill pressure, feet H\(_2\)O absolute
- \( P_o \) = Maximum operating pressure, feet H\(_2\)O absolute

<table>
<thead>
<tr>
<th>INSTALLATION EXPANSION EQUIVALENT DIRECT RADIATION (square feet)</th>
<th>TANK CAPACITY (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 350</td>
<td>18</td>
</tr>
<tr>
<td>Up to 450</td>
<td>21</td>
</tr>
<tr>
<td>Up to 650</td>
<td>24</td>
</tr>
<tr>
<td>Up to 900</td>
<td>30</td>
</tr>
<tr>
<td>Up to 1100</td>
<td>35</td>
</tr>
<tr>
<td>Up to 1400</td>
<td>40</td>
</tr>
<tr>
<td>Up to 1600</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 1800</td>
<td>2 to 30</td>
</tr>
<tr>
<td>Up to 2000</td>
<td>2 to 35</td>
</tr>
<tr>
<td>Up to 2400</td>
<td>2 to 40</td>
</tr>
</tbody>
</table>

Notes:

1. Based on a two-pipe system with an average operating water temperature of \(170^\circ\)F (77°C), using cast-iron column radiation with a heat emission rate of 150 British thermal units per square foot hour [Btu/(ft\(^2\)•h)] (473 W/m\(^2\)) equivalent direct radiation.
2. For systems that exceed 2400 square feet (229.9 m\(^2\)) 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 m\(^2\)) of additional equivalent direct radiation.
TABLE 1004.4(2)
EXPANSION TANK CAPACITIES FOR FORCED HOT WATER SYSTEMS1

<table>
<thead>
<tr>
<th>SYSTEM VOLUME2 (gallons)</th>
<th>TANK CAPACITY DIAHPRAGM TYPE (gallons)</th>
<th>TANK CAPACITY NONDIAPHRAGM TYPE (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>200</td>
<td>17</td>
<td>30</td>
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<tr>
<td>300</td>
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<td>45</td>
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<tr>
<td>400</td>
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<td>500</td>
<td>42</td>
<td>75</td>
</tr>
<tr>
<td>1000</td>
<td>83</td>
<td>150</td>
</tr>
<tr>
<td>2000</td>
<td>165</td>
<td>300</td>
</tr>
</tbody>
</table>

For SI units: 1 gallon = 3.785 L

Notes:
1. Based on an average operating water temperature of 195°F (91°C), a fill pressure of 12 psig (83 kPa), and an operating pressure of not more than 30 psig (207 kPa).
2. Includes volume of water in boiler, radiation, and piping, not including expansion tank.

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 relief valve 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. Shall be of approved material that is rated for the temperature of the system. The discharge pipe shall be of the same diameter as the safety or relief valve outlet.

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), 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 discharged to the outside the boiler room. No valve shall be placed between the safety or relief valve and the boiler, on the discharge pipe between the safety valve and the atmosphere. Discharges from relief valves on industrial boilers shall be discharged to an approved location.

1005.2 Temperature, Pressure, and Vacuum Relief Devices. Temperature, pressure, and vacuum relief devices or combination thereof, and automatic gas shutoff devices shall be installed in accordance with the manufacturer’s installation instructions. A shutoff valve shall not be placed between the relief valve and the pressure vessel or boiler or on the discharge pipe between such valves and the atmosphere. The hourly British thermal units (Btu) (kW•h) discharge capacity of the device shall be not less than the input rating of the pressure vessel or boiler. [NFPA 54.10.28.5]

1005.35 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 down-stream 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- and steam boilers shall be installed with a low-water cutoff. A coil-type boiler or a watertube 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 set point 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 (1465 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 (1465 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 (1465 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+09 Btu/h (3663 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 make 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 in utility occupancies.
1013.3 Maintenance Inspection. The Authority Having Jurisdiction shall inspect boilers and pressure vessels operated under 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- 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 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 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 SHUTOFF</th>
<th>CONTROL AND LIMIT DEVICE SYSTEM DESIGN</th>
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<tbody>
<tr>
<td>A</td>
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<td>Any type</td>
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<td>Not Required</td>
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<td>15</td>
<td>15</td>
<td>2-4</td>
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<td>Not Required</td>
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<tr>
<td>C</td>
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<td>15</td>
<td>15</td>
<td>15</td>
<td>2-4</td>
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<td>15</td>
<td>2-4</td>
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<td>Gas, Oil and/or Coal</td>
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<td>Per NFPA 85</td>
<td>Per NFPA 85</td>
<td>Per NFPA 85</td>
<td>Per ASME Power Boiler Code, Section 1 and NFPA 85</td>
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<td>M</td>
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<td>Per NFPA 85</td>
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<td>Per ASME Boiler &amp; Pressure Code &amp; NFPA 85</td>
<td>Per NFPA 85</td>
<td>Per NFPA 85</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW
1 Fuel input shall be determined by one of the following:

1. The burner input shall not exceed the input shown on the burner nameplate or as otherwise identified by the manufacturer.
2. 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 shutoff 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 nonrecycling 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 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 four 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 shall comply with this chapter and ASHRAE 15.

Exception: Ammonia refrigeration systems shall comply with IIAR 2, IIAR 3, and IIAR 5.

1102.2 Refrigerants. The refrigerant used shall be of a type listed in Table 1102.2 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 1102.2.

1103.2 Classification of Refrigeration Systems. Refrigeration systems shall be classified according to the degree of probability that a leakage of refrigerant is capable of entering an normally occupied 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 is capable of entering will enter an normally occupied occupancy-classified area in accordance with Section 1103.2.1 and Section 1103.2.2. [ASHRAE 15:5.2.1]

1103.2.2 Low-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 is not capable of entering the occupied space shall be classified as low-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 greater that is more than the secondary coolant. [ASHRAE 15:5.2.1]

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 this section.

1104.2 Volume of Occupied Space Refrigerant Concentration Limit. The percentage concentration of refrigerant in a single, complete discharge of an independent circuit of a high-probability system shall not exceed the amounts shown in Table 1102.2, except as provided in Section 1104.3 and Section 1104.4, based on. The volume of the occupied space shall be determined in accordance with Section 1104.2.1 through Section 1104.2.3. The volume of the smallest, enclosed, occupied space shall be used to determine the permissible quantity of refrigerant in a system that is located in, serves, or passes through such space. In accordance to this section, occupied space shall include those rooms that are occupied occasionally for short periods of time such as storage rooms, equipment rooms other than refrigeration machinery rooms, or a room which is capable of being entered with a door that is capable of being closed after entry.

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]
Where the airflow to an enclosed space served by a portion of an air duct system cannot be shut off or reduced below one-quarter of its maximum, the cubical contents of the entire space served by that portion of the air duct system shall be used to determine the permissible quantity of refrigerant in the system.

(2) Refrigerated process or storage areas that comply with the requirements of Section 1104.3:

1104.2 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 15:7.3.3.1]

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 of the smallest volume in which the leaked refrigerant disperses shall be used to determine the refrigerant quantity limit, 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 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 where calculating the refrigerant quantity limit in the system. [ASHRAE 15:7.3.2.3]

1104.3 Institutional Occupancies. The amounts shown in Table 1102.2 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. [ASHRAE 15:7.2.1]

1104.4 Industrial Occupancies and Refrigerated Rooms 1104.3 Refrigerated Process and Storage Areas. Refrigerant quantities in evaporators and piping within rooms or spaces used exclusively for processing or storage of materials under refrigerated conditions shall not be limited, provided that existing is provided in accordance with the building code and in accordance with Table 1104.1 through Section 1104.3.3. Section 1104.2 shall not apply in industrial occupancies and refrigerated rooms where in accordance with the following:

(1) 1104.3.2 Sealed. The refrigerated room or space is sealed from other portions of the building by vapor tight construction, and tight-fitting, gasketed doors. The space(s) containing the machinery is (are) separated from other occupancies by tight construction with tight-fitting doors.

Exception: Adjoining refrigerated rooms.

(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) 1104.3.1 Refrigerant Room. The refrigerated room or space is equipped with a refrigerant vapor detection and alarm system that is in accordance with Section 1104.4 Refrigerant detectors are installed with the sensing location and alarm level as required in refrigeration machinery rooms in accordance with Section 1106.4.

(5) Open flames and surfaces exceeding 800°F (427°C) shall not be permitted where a Group A2, B2, A3, or B3 refrigerant, other than R-717 (ammonia), is used.

(6) 1104.3.3 Lower Flammability Limit. Where the quantity of Group A2, B2, A3, or B3 refrigerant other than ammonia, in an independent circuit will exceed 25 percent of the lower flammability limit where released to the surrounding room, the following shall be provided:

(4) Electrical equipment shall comply with the requirements of the electrical code for Class I, Division 2.

(2) The refrigerant vapor detection system required by Section 1104.3.1 shall automatically de-energize ele-
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, and connecting piping, are located in a machinery room or outdoors. [ASHRAE 15:7.2.2]

### 1104.45 All Occupancies Flammable Refrigerants.

The quantity total of Group A2, B2, A3, and B3 refrigerants, other than R-717 (ammonia), shall not exceed 1100 pounds (498.9 kg) unless approved without approval by the Authority Having Jurisdiction. [ASHRAE 15:7.5.1.1]

### 1104.56 Applications for Human Comfort.

In nonindustrial occupancies, Group A2, A3, B1, B2, and B3 refrigerants shall not be used in high-probability systems for human comfort. [ASHRAE 15:7.5.2]

### 1104.67 Refrigerant Type and Purity.

Refrigerants shall be of a type specified by the equipment manufacturer. Unless otherwise specified by the equipment manufacturer, refrigerants used in new equipment shall be of a purity in accordance with AHRI 700.

#### 1104.67.1 Recovered Refrigerants.

Recovered refrigerants shall not be reused except in the system from which they were removed or as provided in Section 1104.67.2 or Section 1104.67.3. Where contamination is evident by discoloration, odor, acid test results, or system history, recovered refrigerants shall be reclaimed in accordance with Section 1104.67.3. [ASHRAE 15:7.5.1.4]

#### 1104.67.2 Recycled Refrigerants.

Recycled refrigerants shall not be reused except in systems using the same refrigerant and lubricant designation and belonging to the same owner as the systems from which they were removed. Where contamination is evident by discoloration, odor, acid test results, or system history, recycled refrigerants shall be reclaimed in accordance with Section 1104.67.3.

**Exception:** Drying shall not be required in order to use recycled refrigerants where water is the refrigerant, is used as an absorbent, or is a deliberate additive. [ASHRAE 15:7.5.1.5]

#### 1104.67.3 Reclaimed Refrigerants.

Used refrigerants shall not be reused in a different owner’s equipment unless tested and found to be in accordance with the requirements of AHRI 700. Contaminated refrigerants shall not be used unless reclaimed and in accordance with AHRI 700. [ASHRAE 15:7.5.1.6]

### 1104.67.4 Mixing.

Refrigerants, including refrigerant blends, with different designations as in accordance with Table 1102.2 shall not be mixed in a system.

**Exception:** Addition of a second refrigerant is permitted where specified by the equipment manufacturer to improve oil return at low temperatures. The refrigerant and amount added shall be in accordance with the manufacturer’s instructions. [ASHRAE 15:7.5.1.7]

### 1104.78 Changing Refrigerants.

A change in the type of refrigerant in a system shall not be made without notifying the Authority Having Jurisdiction, the user, and due observance of safety requirements. The refrigerant being considered shall be approved evaluated for suitability. [ASHRAE 15:5.3]

### 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 904.7 904.6 and Section 904.4. 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 1104.56.

#### 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. Equipment containing Group A1 refrigerants shall be permitted to be supported by the same materials permitted for the building type.
2. 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 use portable means of access.
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 by 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 furred space shall be permitted to be provided an 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 of this code.

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.
(2) Equipment located on the roof or on the exterior walls of a building.

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 1107.0.

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 a 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).

1105.6 Prohibited Locations. Refrigeration systems or portions thereof shall not be located within a required exit enclosure. Refrigeration compressors exceeding 5 horsepower (3.7 kW) rating shall be located not less than 10 feet (3048 mm) from an exit opening in a Group A; Group B; Group E; Group F; Group I; Group R, Division 1; or Group S Occupancy, unless separated by a one-hour fire-resistive occupancy separation.

1105.7 Condensate. Condensate from air-cooling coils shall be collected and drained to an approved location. Drain pans and coils shall be arranged to allow thorough drainage and access for cleaning. Where temperatures drop below freezing, heat tracing and insulation of condensate drains shall be installed.

1105.8 Defrost. Where defrost cycles are required for portions of the system, provisions shall be made for collection and disposal of the defrost liquid in a safe and sanitary manner.

1105.9 Overflows. Where condensate or defrost liquids are generated in an attic or furred space and structural damage will result from overflow, provisions for overflow shall be provided.

1105.10 Condensate, Defrost, and Overflow Disposal. Disposal of condensate, defrost, or overflow discharges shall comply with Section 310.0.

1105.11 Refrigerant Port Protection. Air conditioning refrigerant circuit access ports located outdoors shall be protected from unauthorized access with locking-type tamper-resistant caps or in a manner approved by the Authority Having Jurisdiction.

Exception: Refrigerant ports in secure locations protected by walls or fencing and requiring key-access.

1105.12 Storage. Refrigerants and refrigerant oils not charged within the refrigeration system shall be stored in accordance with Section 1105.12.1 and the fire code. Storage of materials in a refrigeration machinery room shall comply with the fire code.

1105.12.1 Quantity. The amount of refrigerant stored in a machinery room in 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]

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 1102.2.

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 Refrigerant. The system contains other than a Group A1 refrigerant.

Exceptions:
(1) Lithium bromide absorption systems using water as the refrigerant.
(2) Ammonia-water absorption unit systems installed outdoors, provided that the quantity of refrigerant in a single system does not exceed Table 1102.2 amounts and the discharge is shielded and dispersed.
(3) Systems containing less than 300 pounds (136.1 kg) of refrigerant R-123 and located in an approved exterior location.
(4) Systems containing less than 35 pounds (15.9 kg) of refrigerant R-717 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 1104.3 1104.4, discharge piping required of this chapter, and cooling towers regulated by Part II of this chapter, and their essential piping.

1106.2 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.

1106.3 Exits. Exits shall comply with the building code for special hazards.

1106.4 Refrigerant-Vapor Alarms. Machinery rooms shall be provided with one or more approved refrigerant-vapor detectors sensing where a leak is likely to concentrate. The detector(s) shall be configured to activate two separate alarms at concentrations not greater than the following:
(1) Alarm 1: 25 percent of the LFL, 50 percent of the IDLH, or the OEL, whichever is less.
(2) Alarm 2: 25 percent of the LFL or the vapor detector’s upper detection limit, whichever is less. This alarm shall not be required for Group A1 and B1 refrigerants.

Alarm 1 shall activate visual and audible alarms inside the refrigerating machinery room and outside each entrance to the refrigerating machinery room, and shall activate mechanical ventilation in accordance with Section 1107.6 and emergency shutoff in accordance with Section 1108.3. The alarms shall be of the manual reset type with the reset located inside the refrigerating machinery room. Alarms shall provide a sound pressure level of not less than 15 decibels (dB) above the operating ambient noise sound pressure level of the space in which they are installed and provide an approved visual alarm.

Alarms set at other refrigerant concentration levels shall be permitted in addition to those required by this section provided the meaning of each alarm is marked by signage or displays near the annunciators.

1106.5 Separation. Refrigeration machinery rooms shall be separated from other portions of the building, as required in the special hazards provisions of the building code. Penetrations shall be sealed to inhibit the passage of refrigerant vapor.

1106.6 Combustion Air and Return Air. No open flames that use combustion air or return air shall not be taken from or through a refrigeration 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 1106.4, shall be installed to automatically shut down the combustion process in the event of refrigerant leakage.

Exceptions:
(1) Refrigeration machinery rooms used exclusively for direct-fired absorption equipment Machinery rooms where carbon dioxide (R-744) or water (R-718) is the refrigerant.
(2) Direct-vented combustion equipment Machinery rooms where ammonia (R-717) is the refrigerant and internal combustion engines are used as the prime mover for the compressors. [ASHRAE 15:8.11.6]

1106.7 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 a 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]

1106.78 Special Requirements. Open flames or devices having an exposed surface exceeding 800°F (427°C) are prohibited in refrigeration machinery rooms.

Exceptions:
(1) Momentary temperature excursions such as electrical contacts in A1 and B1 systems.
(2) Refrigeration machinery rooms used exclusively for direct-fired absorption equipment.

1107.0 Refrigeration Machinery Room Ventilation.
1107.1 General. Refrigeration machinery rooms shall be provided with a source of outside air for ventilation and removal of rejected heat.

1107.2 Refrigeration Machinery Rooms. Refrigeration machinery rooms shall be provided with dedicated mechan-
ical exhaust systems. The exhaust systems shall have the capacity to provide emergency purge of escaping refrigerant at a rate of 30 air changes per hour (ACH) for ammonia, or for other refrigerants as determined in accordance with Equation 1107.2:

\[ Q = 100 \sqrt{G} \]  

[Equation 1107.2]

Where:

\( Q \) = Air-flow rate, cubic feet per minute.
\( G \) = Refrigerant mass in largest system, pounds.

1107.3 Natural Ventilation. Natural ventilation shall be permitted where the machinery room is located outdoors more than 20 feet (6096 mm) from a building 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:

(a) The free-aperture cross sectional free opening area for the ventilation of a machinery room shall be not less than as determined in accordance with Equation 1107.3. The location of the gravity ventilation openings shall be based on the relative density of the refrigerant to air:

\[ F = \sqrt{G} \]  

(Equation 1107.3)

Where:

\( F \) = The free opening area, square feet.
\( G \) = The refrigerant mass of refrigerant in the largest system, any part of which is located in the machinery room, pounds. [ASHRAE 15:8.11.5(c), (d)]

For SI units: 1 square foot = 0.0929 m², 1 pound = 0.453 kg

(b) 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)]

1107.4 Distribution of Ventilation. Exhaust inlets or permanent openings shall be located to provide ventilation throughout the entire refrigeration machinery room.

1107.5 Use of Ventilation Systems for Other Purposes. Fans providing refrigeration machinery room refrigerant exhaust in accordance with Section 1107.2 shall be permitted to be automatically or manually controlled to provide intermittent ventilation where the machinery room is occupied or in accordance with Section 1107.10.

1107.6 Emergency Control of the Ventilation Systems. Fans required by Section 1107.2 to provide emergency purge ventilation shall be activated by refrigerant Alarm 1 in accordance with Section 1106.4 and by a clearly identified switch of the break-glass type, or protected by an approved tamper-resistant cover located immediately adjacent to and outside of the principal refrigeration machinery entrance. Two colored and labeled indicator lamps responding to the differential pressure across the purge fan or current through the fan motor shall be provided for each switch. One lamp shall indicate flow; the other shall indicate no flow.

1107.7 Ventilation Discharge. Exhaust from mechanical ventilation systems shall comply with Section 502.2.2.

1107.8 Fans. Fans and associated equipment intended to operate the emergency purge of other than Group A1 or Group B1 refrigerants shall be in accordance with the requirements for a Class I, Division 1 hazardous location as specified in the electrical code.

1107.9 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.

1107.10 Maximum Temperature. Ventilation or mechanical cooling systems shall be provided to maintain a temperature of not more than 104°F (40°C) in the refrigeration machinery room under design load and weather conditions.

1107.11 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]

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 1107.8.

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 B1 refrigerants, emergency shutoff shall be automatically activated by refrigerant Alarm 2 in accordance with Section 1106.4.

1108.4 Detection and Alarm Systems. Detection and alarm systems in accordance with Section 1106.4 for other
109.0 Refrigeration Piping, Containers, and Valves.

109.1 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]

109.1.1 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.

109.1.2 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.

109.1.3 Aluminum, Zinc, Magnesium. 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]

109.2 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 brass copper alloy pipe joints of iron pipe size shall be of approved threaded, flanged, or brazed types. Copper tubing joints and connections shall be approved flared, lapped, swaged, or brazed joints. Piping and tubing shall be installed so as to prevent vibration and strains at joints and connections.

109.3 Penetration of Piping. Refrigerant piping shall be permitted to not penetrate floors, ceilings, or roofs where installed in accordance with the following:

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 1102.2 for the smallest occupied space through which the refrigerant piping passes.

(5) In other than nonindustrial occupancies and where the refrigerant concentration exceeds that listed in Table 1102.2 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]

109.4 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]

109.5 Underground Piping. Refrigerant piping placed underground shall be protected against corrosion.

109.5.1 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 15:8.10.2]

109.6 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.

109.7 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 1½ inches (35 mm) nominal size. Mechanical joints shall not be made on tubing exceeding ⅞ 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 be 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 having 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 be 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 and outlet 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.

**Exceptions:**

1. Where the receiver is an integral part of the condenser or condensing unit, it shall not require a stop valve at the inlet.

1111.0 Pressure-Limiting Devices.

1111.1 Where Required. Pressure-limiting devices shall be provided on systems operating above atmospheric pressure.

**Exception:** 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 high-side 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 high-side 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 be permitted to be more not required to be less than the design pressure of the high-side of the system provided the pressure-relief device is located in the low-side, subject to lowside pressure, and there is a permanent (unvalved) relief path between the high-side and the low-side of the system. [ASHRAE 15:9.9.2]

1111.3 Connection. Pressure-limiting devices shall be connected between the pressure-imposing element and the stop valve on the discharge side. There shall be no without intervening stop valves in the line leading to the pressure-limiting device. [ASHRAE 15:9.9.3]

1111.4 Operation. 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.

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.

Exceptions: 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 working design pressures due to temperature rise, shall be protected by the installation of pressure-relief devices.

1112.4 Evaporators. Evaporators located downstream, or upstream within 18 inches (457 mm), of a heating coil shall be fitted with a pressure-relief device discharging outside the building in accordance with the requirements of Section 1112.10.

Exceptions:

(1) Relief valves shall not be required on heating coils that are capable of producing designed to produce a temperature that will result in the saturation pressure of the refrigerant being less than the design pressure.

(2) A relief valve shall not be required on self-contained or unit systems where the volume of the low-side 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.

\[
\frac{V_1}{W_1 - \left(\frac{V_2}{V_{gt}}\right)} > V_{gc}
\]  
(Equation 1112.4)

Where:

\[
V_1 = \text{Low-side volume, cubic foot.}
\]
\[
V_2 = \text{Total volume of system, cubic foot.}
\]
\[
W_1 = \text{Total weight of refrigerant in system, pounds.}
\]
\[
V_{gt} = \text{Specific volume of refrigerant vapor at 110°F, cubic feet per pound.}
\]
\[
V_{gc} = \text{Specific volume at critical temperature and pressure, cubic feet per pound. [ASHRAE 15:9.4.4]}
\]

1112.5 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 open automatically at the set pressure and, where essential part of the pilot fails, shall discharge its full rated capacity. [ASHRAE 15:9.4.5]

1112.6 Stop Valves Prohibited. Stop valves shall not be located between a pressure-relief device and parts of the system protected thereby. A three-way valve, used in conjunction with the dual relief valve in accordance with Section 1113.4, shall not be considered a stop valve. [ASHRAE 15:9.4.6]

1113.3 1112.7 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 high side, they shall be located above or below the liquid refrigerant level. [ASHRAE 15:9.4.8]

1112.78 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]

1112.89 Pressure-Relief Device Settings. Pressure-relief valves shall actuate 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]

1112.89.1 **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 need not be larger but shall not be smaller than the relief-valve inlet. [ASHRAE 15:9.5.2]

1112.10 **Discharge from Pressure-Relief Devices.** Pressure-relief systems designed for vapor shall comply with Section 1112.10.1 through Section 1112.10.4.1.

1112.10.1 **Discharging Location Interior to Building.** Pressure-relief devices, including fusible plugs, serving refrigeration systems shall be permitted to discharge to the interior of a building where in accordance with the following:

1. The system contains less than 110 pounds (49.9 kg) of a Group A1 refrigerant.
2. The system contains less than 6.6 pounds (2.99 kg) of a Group A2, B1 or B2 refrigerant.
3. The system does not contain any quantity of a Group A3 or B3 refrigerant.
4. The system is not required to be installed in a machinery room in accordance with Section 1106.0.
5. The refrigerant concentration limits in Section 1104.0 are not exceeded. Refrigeration systems that do not comply with the above requirements shall comply with the requirements of Section 1112.10.2 through Section 1112.10.4. [ASHRAE 15:9.7.8.1]

1112.10.2 **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]

1112.10.3 **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 exceeding 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]
1112.10.4 Discharge Location, Special Requirements. Additional requirements for relief device discharge location and allowances shall apply for specific refrigerants in accordance with Section 1112.10.4.1. [ASHRAE 15:9.7.8.4]

1112.10.4.1 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]

1112.9.1 Discharge Piping. The piping used for pressure-relief device discharge shall be in accordance with Section 1112.11.1 through Section 1112.11.5. [ASHRAE 15:9.7.9]

1112.11.1 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]

1112.11.2 Pipe Size. The size of the discharge pipe from the pressure-relief device or fusible plug shall be not less than the outlet size of the pressure-relief device or fusible plug. Where outlet of two or more relief devices or fusible plugs are connected to a common line or header, the effect of back pressure that will be developed where more than one relief device or fusible plug operates shall be considered. The sizing of the common discharge header downstream from the two or more relief devices or fusible plugs that operate simultaneously shall be based on the sum of their outlet areas and the pressure drops in downstream sections. [ASHRAE 15:9.7.8.49.7.9.2]

1112.11.3 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 1112.11.4 and Section 1112.11.5. [ASHRAE 15:9.7.8.49.7.9.3]

TABLE 1112.11.3

<table>
<thead>
<tr>
<th>ELEVATION ABOVE SEA LEVEL, FEET</th>
<th>POUNDS PER SQUARE INCH, ABSOLUTE (pₐ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.7</td>
</tr>
<tr>
<td>500</td>
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<tr>
<td>9000</td>
<td>10.5</td>
</tr>
<tr>
<td>10000</td>
<td>10.1</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1 pound-force per square inch = 6.8947 kPa.

1112.11.4 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 1112.11.4(1).

\[ L = \frac{0.2146 \cdot d^2}{f C_r^2} \left( \frac{P_2 - P_1}{P_2 - P_0} \right) \cdot \frac{d \ln (E_{eq})}{6 f} \]  

Where:
- \( C \) = Minimum required discharge capacity, pounds per minute.
- \( L \) = Equivalent length of discharge piping, inches.
- \( C_r \) = 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 1112.13 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.
The discharge shall be terminated to prevent both the discharged refrigerant from being sprayed directly on personnel in the vicinity and foreign material or debris from entering the discharge piping. Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging the pipe where the fusible plug or rupture member functions. Systems using water as the refrigerant are permitted to discharge to a floor drain where in accordance with the following:

(1) The pressure relief device set pressure does not exceed 15 psig (103 kPa):

(2) The floor drain is sized to handle not less than the flow rate from a single broken tube in a refrigerant containing heat exchanger.

(3) The additives used in the refrigeration system shall be approved by the Authority Having Jurisdiction or a catch tank shall be installed, sized to handle the expected discharge, and shall be equipped with a normally closed drain valve and an overflow line to the drain. [ASHRAE 15:9.7.8]

### 1112.112 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]

### 1112.123 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:

$$ C = 0.64 P_d d^2 $$ [Equation 1112.123(1)]

$$ d = 1.25 \sqrt{C/P_1} $$ [Equation 1112.123(2)]

Where:

- $C$ = Rated discharge capacity of air pounds per minute.
- $d$ = Smallest internal diameter of the inlet pipe, retaining flanges, fusible plug, rupture member inches.

For rupture members:

$$ P_1 = (\text{rated pressure in psig } \times 1.1) + 14.7 $$ [Equation 1112.123(3)]

For fusible plugs:

$$ P_r = \text{Absolute saturation pressure, corresponding to the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, pound-force per square inch atmosphere, psia.} $$ [ASHRAE 15:9.7.7]
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 fuse 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] Pressure vessels having inside dimension of 6 inches (152 mm) or less shall be protected by a pressure-relief device or fusible plug.

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 devices or fusible plug for a pressure vessel shall be not less than the capacity determined in accordance with Equation 1113.5:

\[ C = fDL \]  

Where:
\[ C = \text{Minimum required discharge capacity of the relief device expressed as mass flow of air, in pounds of air per minute.} \]
\[ D = \text{Outside diameter of vessel, feet.} \]
\[ L = \text{Length of vessel, feet.} \]
\[ f = \text{Factor dependent upon type of refrigerant from Table 1113.5.} \]

Where combustible materials are used within 20 ft (6096 mm) of a pressure vessel, the value of \( f \) shall be multiplied 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 pressure vessel, the required capacity shall be the sum of the capacity required for every pressure vessel. [ASHRAE 15:9.7.5]

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 outdoors atmosphere. Dual pressure-relief valves shall be installed with a three-way valve to allow testing or repair. Where dual pressure 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 low-side of the system.
(2) The vessel is provided with shutoff valves designed to allow pumpdown of the refrigerant charge of the pressure vessel.

### Table 1113.5

<table>
<thead>
<tr>
<th>Refrigerant</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>
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) Ammonia absorption systems serving a single dwelling unit.
(2) 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.
(3) 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 threat of fire. Standby fuel, such as LPG, 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 by an approved assembler in accordance with ASME BPVC Section VIII. Pressure-relief valves 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 permitted to 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) to show compliance with this chapter. [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 high-side of each factory-assembled refrigerating system shall be not less than the design pressure of the high-side. The test pressure applied to the low-side of a factory-assembled refrigerating system shall be not less than the design pressure of the low-side. [ASHRAE 15:9.14.2]

1116.1.3 Design Pressure of 15 psig or Less. Exception: Units with a design pressure of not more than 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 low-side 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 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.

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 gauge 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 of a refrigerant weight fraction (mass fraction) 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 refrigerants shall be permitted for tests where the system is subsequently evacuated to less than 1000 microns (0.1333 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.
(4) Systems erected on the premises using Group A1 refrigerant and with copper tubing not exceeding 0.62 of an inch (15.7 mm) outside diameter shall be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at not less than 68°F (20°C). [ASHRAE 15:10.1.2]

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 high side and the low side 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 individually or as part of an assembly.
(2) Marked directly on the vessel or on a nameplate attached to the vessel in accordance with ASME BPVC Section VIII.

TABLE 1116.2
FIELD LEAK TEST PRESSURES (psig)*

<table>
<thead>
<tr>
<th>REFRIGERANT NUMBER</th>
<th>HIGH SIDE WATER COOLED</th>
<th>HIGH SIDE AIR COOLED</th>
<th>LOW SIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
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<td>123</td>
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<td>15</td>
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<td>134a</td>
<td>150</td>
<td>250</td>
<td>150</td>
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<td>130</td>
<td>220</td>
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<td>500</td>
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<tr>
<td>717</td>
<td>235</td>
<td>390</td>
<td>235</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).
1117.1.1 Pressure-Relief Device. Where a pressure-relief device 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 of not less than 3.0 times the design pressure. [ASHRAE 15:9.3.1.1]

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 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.

114920.0 Support and Anchorage.
114920.1 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.

11201.0 Drainage.
11201.1 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.

1124.0 Chemical Treatment Systems.
1124.1 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.

1124.2 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.

1124.3 Location.
1124.1 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.

1124.4 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.

1124.5 Refrigerants and Hazardous Fluids.
1124.1 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 the fire code.

1125.0 Drift Eliminators.
1125.1 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 NAME (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP</th>
<th>OEL (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-13</td>
<td>CClF₃</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-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>
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<td>—</td>
</tr>
<tr>
<td>R-50</td>
<td>CH₄</td>
<td>Methane</td>
<td>A3</td>
<td>1000*</td>
<td>—</td>
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<tr>
<td>R-113</td>
<td>CCl₃FCClF₂</td>
<td>1, 1, 2-trichloro-1, 2, 2-trifluoroethane</td>
<td>A1</td>
<td>1000</td>
<td>1.2</td>
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<tr>
<td>R-114</td>
<td>CClF₂CClF₂</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>CClF₂CF₃</td>
<td>Chloropentafluoroethane</td>
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<td>47</td>
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<tr>
<td>R-116</td>
<td>CF₃CF₃</td>
<td>Hexafluorocarbon</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>
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<td>50*</td>
<td>3.5</td>
</tr>
<tr>
<td>R-124</td>
<td>CHClFCF₃</td>
<td>2-chloro-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, 2-tetrafluoroethane</td>
<td>A1</td>
<td>1000*</td>
<td>13</td>
</tr>
<tr>
<td>R-141b</td>
<td>CH₃CCl₂F</td>
<td>1, 1-dichloro-1-fluoroethane</td>
<td>A1</td>
<td>500*</td>
<td>0.78</td>
</tr>
<tr>
<td>R-142b</td>
<td>CH₃CClF₂</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>CH₃CH₂</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-227ca</td>
<td>CF₃CHFCF₃</td>
<td>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>
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<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>
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<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-C318</td>
<td>-(CF₂)₄-</td>
<td>Octafluorocyclobutane</td>
<td>A1</td>
<td>1000*</td>
<td>41</td>
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<tr>
<td>R-400</td>
<td>zeotrope</td>
<td>R-12/114 (50.0/50.0)</td>
<td>A1</td>
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<td>10</td>
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<td>R-400</td>
<td>zeotrope</td>
<td>R-12/114 (60.0/40.0)</td>
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<td>11</td>
</tr>
<tr>
<td>R-401A</td>
<td>zeotrope</td>
<td>R-22/152a/124 (53.0/13.0/34.0)</td>
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<td>1000*</td>
<td>6.6</td>
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<tr>
<td>R-401B</td>
<td>zeotrope</td>
<td>R-22/152a/124 (61.0/11.0/28.0)</td>
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<td>1000*</td>
<td>7.2</td>
</tr>
<tr>
<td>R-401C</td>
<td>zeotrope</td>
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<td>A1</td>
<td>1000*</td>
<td>5.2</td>
</tr>
<tr>
<td>REFRIGERANT</td>
<td>CHEMICAL FORMULA</td>
<td>CHEMICAL NAME (COMPOSITION FOR BLENDS)</td>
<td>SAFETY GROUP</td>
<td>OEL (ppm)</td>
<td>POUNDS PER 1000 CUBIC FEET OF SPACE</td>
</tr>
<tr>
<td>-------------</td>
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<td>-----------</td>
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</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>
<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-125/143a/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>—</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-408A</td>
<td>zeotrope</td>
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<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>
<td>7.1</td>
</tr>
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<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>
<td>7.3</td>
</tr>
<tr>
<td>R-410A</td>
<td>zeotrope</td>
<td>R-32/125 (50.0/50.0)</td>
<td>A1</td>
<td>1000*</td>
<td>26</td>
</tr>
<tr>
<td>R-410B</td>
<td>zeotrope</td>
<td>R-32/125 (45.0/55.0)</td>
<td>A1</td>
<td>—</td>
<td>27</td>
</tr>
<tr>
<td>R-411A</td>
<td>zeotrope</td>
<td>R-1270/22/152a (1.5/87.5/11.0)</td>
<td>A2</td>
<td>990*</td>
<td>2.9</td>
</tr>
<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>
</tr>
<tr>
<td>R-412A</td>
<td>zeotrope</td>
<td>R-22/18/142b (70.0/50.0/25.0)</td>
<td>A2</td>
<td>1000*</td>
<td>5.1</td>
</tr>
<tr>
<td>R-413A</td>
<td>zeotrope</td>
<td>R-218/134a/600a (9.0/88.0/3.0)</td>
<td>A2</td>
<td>1000</td>
<td>5.8</td>
</tr>
<tr>
<td>R-414A</td>
<td>zeotrope</td>
<td>R-22/124/600a/142b (51.0/28.5/4.0/16.5)</td>
<td>A1</td>
<td>1000*</td>
<td>6.4</td>
</tr>
<tr>
<td>R-414B</td>
<td>zeotrope</td>
<td>R-22/124/600a/142b (50.0/39.0/1.5/9.5)</td>
<td>A1</td>
<td>1000</td>
<td>6.0</td>
</tr>
<tr>
<td>R-415A</td>
<td>zeotrope</td>
<td>R-22/152a (82.0/18.0)</td>
<td>A2</td>
<td>1000</td>
<td>2.9</td>
</tr>
<tr>
<td>R-415B</td>
<td>zeotrope</td>
<td>R-22/152a (25.0/75.0)</td>
<td>A2</td>
<td>1000</td>
<td>2.1</td>
</tr>
<tr>
<td>R-416A</td>
<td>zeotrope</td>
<td>R-134a/124/600 (59.0/39.5/1.5)</td>
<td>A1</td>
<td>1000</td>
<td>3.9</td>
</tr>
<tr>
<td>R-417B</td>
<td>zeotrope</td>
<td>R-135/134a/600 (46.6/50.0/3.4)</td>
<td>A1</td>
<td>1000</td>
<td>3.5</td>
</tr>
<tr>
<td>R-417C</td>
<td>zeotrope</td>
<td>R-135/134a/600 (79.0/18.3/2.7)</td>
<td>A1</td>
<td>1000</td>
<td>4.3</td>
</tr>
<tr>
<td>R-418A</td>
<td>zeotrope</td>
<td>R-135/134a/600 (19.5/78.8/1.7)</td>
<td>A1</td>
<td>1000</td>
<td>5.4</td>
</tr>
<tr>
<td>R-419A</td>
<td>zeotrope</td>
<td>R-290/22/152a (1.5/96.0/2.5)</td>
<td>A2</td>
<td>1000</td>
<td>4.8</td>
</tr>
<tr>
<td>R-419B</td>
<td>zeotrope</td>
<td>R-125/134a/E170 (77.0/19.0/4.0)</td>
<td>A2</td>
<td>1000</td>
<td>4.2</td>
</tr>
<tr>
<td>R-420A</td>
<td>zeotrope</td>
<td>R-125/134a/E170 (48.5/48.0/3.5)</td>
<td>A2</td>
<td>1000</td>
<td>4.6</td>
</tr>
<tr>
<td>R-421A</td>
<td>zeotrope</td>
<td>R-125/134a (58.0/42.0)</td>
<td>A1</td>
<td>1000</td>
<td>12</td>
</tr>
<tr>
<td>R-421B</td>
<td>zeotrope</td>
<td>R-125/134a (85.0/15.0)</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-422A</td>
<td>zeotrope</td>
<td>R-125/134a/600a (85.1/11.5/3.4)</td>
<td>A1</td>
<td>1000</td>
<td>18</td>
</tr>
<tr>
<td>R-422B</td>
<td>zeotrope</td>
<td>R-125/134a/600a (55.0/42.0/3.0)</td>
<td>A1</td>
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<td>16</td>
</tr>
<tr>
<td>R-422C</td>
<td>zeotrope</td>
<td>R-125/134a/600a (82.0/15.0/3.0)</td>
<td>A1</td>
<td>1000</td>
<td>18</td>
</tr>
<tr>
<td>R-422D</td>
<td>zeotrope</td>
<td>R-125/134a/600a (65.1/31.5/3.4)</td>
<td>A1</td>
<td>1000</td>
<td>16</td>
</tr>
<tr>
<td>R-422E</td>
<td>zeotrope</td>
<td>R-125/134a/600a (58.0/39.3/2.7)</td>
<td>A1</td>
<td>1000</td>
<td>16</td>
</tr>
<tr>
<td>R-423A</td>
<td>zeotrope</td>
<td>R-134a/227ea (52.5/47.5)</td>
<td>A1</td>
<td>1000</td>
<td>19</td>
</tr>
<tr>
<td>R-424A</td>
<td>zeotrope</td>
<td>R-125/134a/600a/600/601a (50.5/47.0/0.9/11.0/0.6)</td>
<td>A1</td>
<td>970</td>
<td>6.2</td>
</tr>
</tbody>
</table>
TABLE 1102.2 (continued)
REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES1,2,3
[ASHRAE 34: TABLE 4-1, TABLE 4-2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA3</th>
<th>CHEMICAL NAME4 (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP5</th>
<th>OEL6 (ppm)</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE8</th>
</tr>
</thead>
<tbody>
<tr>
<td>R425A</td>
<td>zebtope</td>
<td>R-32/134a/227ea (18.5/69.5/12.0)</td>
<td>A1</td>
<td>1000</td>
<td>16</td>
</tr>
<tr>
<td>R426A</td>
<td>zebtope</td>
<td>R-125/134a/600/601a (5.1/93.0/1.3/0.6)</td>
<td>A1</td>
<td>990</td>
<td>5.2</td>
</tr>
<tr>
<td>R427A</td>
<td>zebtope</td>
<td>R-32/125/143a/134a (15.0/25.0/10.0/50.0)</td>
<td>A1</td>
<td>1000</td>
<td>18</td>
</tr>
<tr>
<td>R428A</td>
<td>zebtope</td>
<td>R-125/143a/290/600a (77.5/20.0/0.6/1.9)</td>
<td>A1</td>
<td>1000</td>
<td>23</td>
</tr>
<tr>
<td>R-429A</td>
<td>zebtope</td>
<td>R-E170/152a/600a (60.0/10.0/30.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.81</td>
</tr>
<tr>
<td>R-430A</td>
<td>zebtope</td>
<td>R-152a/600a (76.0/24.0)</td>
<td>A3</td>
<td>1000</td>
<td>1.3</td>
</tr>
<tr>
<td>R-431A</td>
<td>zebtope</td>
<td>R-290/152a (71.0/29.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.69</td>
</tr>
<tr>
<td>R-432A</td>
<td>zebtope</td>
<td>R-1270/E170 (80.0/20.0)</td>
<td>A3</td>
<td>700</td>
<td>0.13</td>
</tr>
<tr>
<td>R-433A</td>
<td>zebtope</td>
<td>R-1270/290 (30.0/70.0)</td>
<td>A3</td>
<td>880</td>
<td>0.34</td>
</tr>
<tr>
<td>R-433B</td>
<td>zebtope</td>
<td>R-1270/290 (5/95.0)</td>
<td>A3</td>
<td>950</td>
<td>0.51</td>
</tr>
<tr>
<td>R-433C</td>
<td>zebtope</td>
<td>R-1270/290 (25.0/75.0)</td>
<td>A3</td>
<td>790</td>
<td>0.41</td>
</tr>
<tr>
<td>R-434A</td>
<td>zebtope</td>
<td>R-125/134a/134a/600a (63.2/18.0/16.0/2.8)</td>
<td>A1</td>
<td>1000</td>
<td>20</td>
</tr>
<tr>
<td>R-435A</td>
<td>zebtope</td>
<td>R-E170/152a (80.0/20.0)</td>
<td>A3</td>
<td>1000</td>
<td>1.1</td>
</tr>
<tr>
<td>R-436A</td>
<td>zebtope</td>
<td>R-290/600a (56.0/44.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.50</td>
</tr>
<tr>
<td>R-436B</td>
<td>zebtope</td>
<td>R-290/600a (52.0/48.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.51</td>
</tr>
<tr>
<td>R-437A</td>
<td>zebtope</td>
<td>R-125/134a/600 (19.5/78.5/4.4/0.6)</td>
<td>A1</td>
<td>990</td>
<td>5.0</td>
</tr>
<tr>
<td>R-438A</td>
<td>zebtope</td>
<td>R-32/125/134a/600a (8.5/45.0/44.2/17.0/6)</td>
<td>A1</td>
<td>990</td>
<td>4.9</td>
</tr>
<tr>
<td>R-439A</td>
<td>zebtope</td>
<td>R-32/125/600a (50.0/47.0/3.0)</td>
<td>A2</td>
<td>990</td>
<td>4.7</td>
</tr>
<tr>
<td>R-440A</td>
<td>zebtope</td>
<td>R-290/134a/152a (0.6/1.6/97.8)</td>
<td>A2</td>
<td>1000</td>
<td>1.9</td>
</tr>
<tr>
<td>R-441A</td>
<td>zebtope</td>
<td>R-170/290/600a/600 (3.1/54.8/6.3/36.1)</td>
<td>A3</td>
<td>1000</td>
<td>0.39</td>
</tr>
<tr>
<td>R-442A</td>
<td>zebtope</td>
<td>R-32/125/134a/152a/227ea (31.0/30.0/30.0/3.0/5.0)</td>
<td>A1</td>
<td>1000</td>
<td>21</td>
</tr>
<tr>
<td>R-443A</td>
<td>zebtope</td>
<td>R-1270/290/600a (55.0/40.0/5.0)</td>
<td>A3</td>
<td>580</td>
<td>0.19</td>
</tr>
<tr>
<td>R-444A</td>
<td>zebtope</td>
<td>R-32/125a/1234ze(E) (12.0/50.0/83.0)</td>
<td>A2L7</td>
<td>850</td>
<td>5.1</td>
</tr>
<tr>
<td>R-445A</td>
<td>zebtope</td>
<td>R-744/134a/1234ze(E) (6.0/9.0/85.0)</td>
<td>A2L7</td>
<td>930</td>
<td>4.2</td>
</tr>
<tr>
<td>R-446A</td>
<td>zebtope</td>
<td>R-32/1234ze(E)/600 (68.0/29.0/3.0)</td>
<td>A2L7</td>
<td>960</td>
<td>2.5</td>
</tr>
<tr>
<td>R-447A</td>
<td>zebtope</td>
<td>R-32/125/1234ze(E) (68.0/3.5/28.5)</td>
<td>A2L7</td>
<td>900</td>
<td>2.6</td>
</tr>
<tr>
<td>R-500</td>
<td>azeotrope</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>azeotrope</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</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</td>
<td>R-23/13 (40.1/59.9)</td>
<td>—</td>
<td>1000</td>
<td>1.0</td>
</tr>
<tr>
<td>R-504</td>
<td>azeotrope</td>
<td>R-32/115 (48.2/51.8)</td>
<td>—</td>
<td>1000</td>
<td>28</td>
</tr>
<tr>
<td>R-507A</td>
<td>azeotrope</td>
<td>R-125/143a (50.0/50.0)</td>
<td>A1</td>
<td>1000*</td>
<td>32</td>
</tr>
<tr>
<td>R-508A</td>
<td>azeotrope</td>
<td>R-23/116 (39.0/61.0)</td>
<td>A1</td>
<td>1000*</td>
<td>14</td>
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<tr>
<td>R-508B</td>
<td>azeotrope</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>azeotrope</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</td>
<td>R-E170/600a (88.0/12.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.87</td>
</tr>
<tr>
<td>R-511A</td>
<td>azeotrope</td>
<td>R-290/E170 (95.0/5.0)</td>
<td>A3</td>
<td>1000</td>
<td>0.59</td>
</tr>
<tr>
<td>R-512A</td>
<td>azeotrope</td>
<td>R-134a/152a (5.0/95.0)</td>
<td>A2</td>
<td>1000</td>
<td>1.9</td>
</tr>
<tr>
<td>R-600</td>
<td>CH₃CH₂CH₂CH₃</td>
<td>Butane</td>
<td>A3</td>
<td>1000</td>
<td>0.15</td>
</tr>
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</table>

REFRIGERATION
## TABLE 1102.2 (continued)

### REFRIGERANT GROUPS, PROPERTIES, AND ALLOWABLE QUANTITIES 1-2-3  
[ASHRAE 34: TABLE 4-1, TABLE 4-2]

<table>
<thead>
<tr>
<th>REFRIGERANT</th>
<th>CHEMICAL FORMULA 2</th>
<th>CHEMICAL NAME 3 (COMPOSITION FOR BLENDS)</th>
<th>SAFETY GROUP 4</th>
<th>OEL 5</th>
<th>POUNDS PER 1000 CUBIC FEET OF SPACE 6</th>
</tr>
</thead>
<tbody>
<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>CH₃CH₂CH₂CH₂C</td>
<td>Pentane</td>
<td>A3</td>
<td>600</td>
<td>0.18</td>
</tr>
<tr>
<td>R-601a</td>
<td>(CH₃)₂CH₂CH₃</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>
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</tr>
<tr>
<td>R-702</td>
<td>H₂</td>
<td>Hydrogen</td>
<td>A3</td>
<td>—</td>
<td>—</td>
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<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>
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<tr>
<td>R-718</td>
<td>H₂O</td>
<td>Water</td>
<td>A1</td>
<td>—</td>
<td>—</td>
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<tr>
<td>R-720</td>
<td>Ne</td>
<td>Neon</td>
<td>A1</td>
<td>—</td>
<td>—</td>
</tr>
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<td>R-728</td>
<td>N₂</td>
<td>Nitrogen</td>
<td>A1</td>
<td>—</td>
<td>—</td>
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<td>R-740</td>
<td>Ar</td>
<td>Argon</td>
<td>A1</td>
<td>—</td>
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<td>R-744</td>
<td>CO₂</td>
<td>Carbon dioxide</td>
<td>A1</td>
<td>5000</td>
<td>4.5</td>
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<tr>
<td>R-764</td>
<td>SO₂</td>
<td>Sulfur dioxide</td>
<td>B1</td>
<td>—</td>
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<tr>
<td>R-1150</td>
<td>CH₂=CH₂</td>
<td>Ethene (ethylene)</td>
<td>A3</td>
<td>200</td>
<td>—</td>
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<tr>
<td>R-1233zd(E)</td>
<td>CF₂=CH=CHCl</td>
<td>Trans-1-chloro-3,3,3-trifluoro-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>
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<tr>
<td>R-1270</td>
<td>CH₃CH=CH₂</td>
<td>Propene (propylene)</td>
<td>A3</td>
<td>500</td>
<td>0.11</td>
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</tbody>
</table>

For SI units: 1 pound = 0.453 kg, 1 cubic foot = 0.0283 m³

### Notes:
1. Refrigerant safety group designation is in accordance with Section 1103.0.
2. Refrigerant properties are those needed for this chapter.
3. Allowable quantities are for high-probability systems under Section 1103.2.
4. Chemical name shown is the preferred name followed by — the popular name is shown in parenthesis.
5. The OEL are 8-hour TWA; a C designation denotes a ceiling limit.
6. Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated.
7. The exact composition of this aze trope is in question, and additional experimental studies are needed.
8. R-507, R-508, and R-509 shall be permitted 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.
9. The amount of refrigerant per occupied space 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.
10. Refrigerant flammability classification of Class 2L shall comply with the requirements for flammability classification of Class 2.
11. Pounds (kg) of refrigerant in a high-probability system per 1000 cubic feet (28.32 m³) of occupied space. See Section 1103.2. This column does not apply to refrigerant machinery rooms or areas covered by Section 1106.0. Where no value is listed use zero unless data is capable of being provided to determine the value in accordance with ASHRAE 34.
12. The OEL value shown is the TLV-C recommended by ACGIH.
13. A OEL has not yet been established; the value given was determined in a consistent manner.
14. The OEL value shown is the WEEL recommended by AIHA.
15. The OEL value shown is the ACGIH TLV-TWA.
16. Quantity is unlimited where R-718 (water) is used as the refrigerant.
17. Flammability classification for this refrigerant is 2L, which is a subclass of class 2.
### TABLE 1104.1
PERMISSIBLE REFRIGERATION SYSTEMS

<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>
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<td>Any</td>
</tr>
<tr>
<td>H-5</td>
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</tr>
<tr>
<td>I-1</td>
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<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>I-2</td>
<td>Group A1(^3) 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(^3) only</td>
<td>Any</td>
<td>Any</td>
</tr>
<tr>
<td>M</td>
<td>Group A1(^2) only</td>
<td>Any</td>
<td>Any</td>
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<tr>
<td>R-1</td>
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<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 1104.3.
3. The allowable quantities shown in Table 1102.2 shall be reduced by 50 percent for institutional occupancies except kitchens, laboratories, and mortuaries.
4. 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, and air conditioning systems. Such piping systems include steam, hot water, chilled water, steam condensate, 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. The temperature of surfaces within reach of building occupants shall not exceed 140°F (60°C) unless they are protected by insulation. Where sleeves are installed, the insulation shall continue full size through them.

Coverings and insulation used for piping shall be of material approved for the operating temperature of the system and the installation environment. Where installed in a plenum, the insulation, jackets, and lap-seal adhesives, including pipe coverings and linings, shall have a flame-spread index not to exceed 25 and a smoke developed index not to exceed 50 where tested in accordance with ASTM E84 or UL 723.

1201.3 Water Hammer. The flow of the hydronic piping system shall be controlled to prevent water hammer.

1201.4 Manifolds. Manifolds shall be equipped with a full-way isolation valve that is fully sealed on the supply and return lines. Manifolds shall be capable of withstanding the pressure and temperature of the system. The material of the manifold shall be compatible with the system fluid and shall be installed in accordance with the manufacturer’s installation instructions.

1201.5 Heat Emitters. Heat emitters shall be installed in accordance with the manufacturer’s installation instructions.

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. Where materials in the hydronic system are not suitable for use in a potable water system, such potable water shall not be used. 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- and water-heating applications both to supply potable hot water and provide hot water for space heating 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>TABLE 1203.2 WATER HEATERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
</tr>
<tr>
<td>Gas, 75 000 Btu/h or less</td>
</tr>
<tr>
<td>Gas, Above 75 000 Btu/h</td>
</tr>
<tr>
<td>Electric, Space Heating</td>
</tr>
<tr>
<td>Solid Fuel</td>
</tr>
</tbody>
</table>

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

1203.3 Tankless Water Heater. The output performance on tankless water heaters 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.

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.

<table>
<thead>
<tr>
<th>TABLE 1204.3</th>
<th>MINIMUM LENGTH OF COLOR FIELD AND SIZE OF LETTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTSIDE DIAMETER OF PIPE OR COVERING (inches)</td>
<td>MINIMUM LENGTH OF COLOR FIELD (inches)</td>
</tr>
<tr>
<td>1/2 to 1 1/4</td>
<td>8</td>
</tr>
<tr>
<td>1 1/2 to 2</td>
<td>8</td>
</tr>
<tr>
<td>2 1/2 to 6</td>
<td>12</td>
</tr>
<tr>
<td>8 to 10</td>
<td>24</td>
</tr>
<tr>
<td>over 10</td>
<td>32</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25.4 mm

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.

1205.3 Flushing. Heat sources, system piping and tubing shall be flushed after installation with water or a cleaning solution. Cleaning of the heat source 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. The heat source shall be disconnected from the piping system or protected with a fine mesh strainer during flushing to prevent debris from being deposited into the heat source.

1205.4 Oxygen Diffusion Corrosion. PEX, PE-RT, and PB tubing in closed hydronic systems shall contain an oxygen barrier.

1206.0 Safety Devices.

1206.1 General. Hydronic systems containing pressurized fluids shall be protected against pressures and temperatures exceeding design limitations with a pressure and temperature relief valve. Each section of the system in which excessive pressures are capable of developing shall have a relief valve located so that a section is not capable of being isolated from a relief device. Pressure and temperature relief valves shall be installed in accordance with the terms of their listing and the manufacturer’s installation instructions.

1206.2 Pressurized Vessels. Pressurized vessels shall be provided with overpressure protection by means of a listed pressure relief valve installed in accordance with the manufacturer’s installation instructions.

1206.3 Discharge Piping. The discharge piping serving a temperature relief valve, pressure relief valve, or combination of both shall have no valves, obstructions, or means of isolation and be provided with the following:

1. 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 floor or a waste receptor, or to the outdoors. The end of the pipe shall not terminate more than 6 inches (152 mm) above the ground and pointing downwards, floor or waste receptor, or extend to the outdoors not less than 6 inches (152 mm) and not more than 24 inches (610 mm) aboveground.
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.

1207.0 Heating Appliances and Equipment.

1207.1 General. Heating appliances, equipment, safety and operational controls shall be listed for its intended use in a hydronic heating system and installed in accordance with the manufacturer’s installation instructions.

1207.2 Boilers. Oil-fired boilers and their control systems shall comply with Section 1002.2.1. Electric boilers shall comply with Section 1002.2. Solid fuel-fired boilers shall comply with UL 2523. Boilers shall be designed and constructed in accordance with Section 1002.1.

1207.2.1 Condensing Boilers. A condensing boiler, in which the heat exchanger and venting system are designed to operate with condensing flue gases, shall be permitted to be connected directly to the panel heating system without a protective mixing device.

1207.2.2 Noncondensing Boilers. Where the heat exchanger and venting system are not designed to operate with condensed flue gases, the boiler shall be permitted to connect directly to the panel heating system where protected from flue gas condensation. The operating temperature of the boiler shall be more than the fluid temperature in accordance with the manufacturer’s instructions.
1207.3 Dual-Purpose Water Heaters. Water heaters used for combined space- and water-heating applications shall be in accordance with CSA Z21.10.1 or CSA Z21.10.3, 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.

1207.3.1 Temperature Limitations. Where a combined space- and water-heating application requires water for space heating at temperatures exceeding 140°F (60°C), a thermostatic mixing valve that is in accordance with ASSE 1017 shall be installed to temper the water supplied to the potable water distribution system to a temperature of 140°F (60°C) or less.

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.

1208.0 Circulators.

1208.1 General. Circulators shall be listed for their intended use based on the heat transfer medium. Circulators shall be installed to allow for service and maintenance. The manufacturer’s installation instructions shall be followed for correct orientation and installation.

1208.2 Mounting. The circulator shall be installed in such a way that strain from the piping is not transferred to the circulator housing. The circulator shall be permitted to be directly connected to the piping, provided the piping is supported on each side of the circulator. Where the installation of a circulator will cause strain on the piping, the circulator shall be installed on a mounting bracket or base plate supported in a manner that will eliminate strain on the piping. Where means for controlling vibration of a circulator is required, an approved means for support and restraint shall be provided.

1208.3 Sizing. The selection and sizing of a circulator 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 velocity, feet per second (m/s)
(4) Maximum and minimum temperature, °F (°C)
(5) Maximum working pressure, pounds per square inch (kPa)
(6) Fluid type

1209.0 Expansion Tanks.

1209.1 Where Required. An expansion tank shall be installed in every hydronic system to control thermal expansion. Secondary hot water systems, that are isolated from the primary system by a heat exchanger shall install a separate expansion tank and pressure relief valve. Expansion tanks shall be of the closed or open type. Expansion tanks used in hydronic systems shall comply with the requirements of ASME Boiler and Pressure Vessel Code Section VIII where the system is designed to operate at more than 30 pounds-force per square inch (psi) (207 kPa) diameter of the tank is greater than 24 inches (610 mm) or where the operating temperature exceeds 250°F (121°C). Tanks shall be rated for the pressure of the system. Expansion tanks shall be accessible for maintenance and shall be installed in accordance with the manufacturer’s installation instructions.

1209.2 Systems with Closed Expansion Tanks. A closed expansion tank shall be sized based on the capacity of the system. The minimum size of the tank shall be determined in accordance with Section 1005.4 and shall be equipped with an airtight tank or other air cushion that is consistent with the volume and capacity of the system. Tanks without membranes shall be equipped with a drain valve and a manual air vent. Tanks shall be located in accordance with the manufacturer’s instructions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

1209.3 Systems with Open Expansion Tanks. An open expansion tank shall be located not less than 36 inches (914 mm) above the highest point in the system and shall be sized based on the capacity of the system. An overflow with a diameter of not less than one-half the size of the water supply or not less than 1 inch (25 mm) in diameter shall be installed at the top of the tank. The overflow shall discharge through an air gap into the drainage system. Isolation valves shall not be installed in the piping between the heat-distribution system and the expansion tank. Tanks shall be located in accordance with the manufacturer’s instructions unless otherwise specified by the system design. Each tank shall be equipped with a shutoff device that will remain open during operation of the heating system. Valve handles shall be locked open or removed to prevent from being inadvertently shut off.

1210.0 Materials.

1210.1 Pipe, Tube, 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 transfer medium. Pipe fittings and valves shall be approved for the installation with the piping, materials to be installed and shall be in accordance with the applicable standards referenced in Table 1210.1. 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 Table 314.3.313.3. Systems with valves, circulators, and expansion tanks shall be provided with additional support in accordance with this code and manufacturer’s installation instructions.

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 having a radius of not less than six times the outside diameter of the tubing 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 Poly (Vinyl Chloride) (CPVC) Pipe. Joints between chlorinated poly (vinyl chloride) (CPVC) pipe or fittings shall be installed in accordance with one of the following methods:

1. Removable and non-removable push fit fittings with an elastomeric O-ring that employ quick assembly push fit connectors listed or labeled 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, \( \frac{1}{2} \) of an inch (15 mm) through 2 inches (50 mm) in diameter or ASTM F442, \( \frac{1}{2} \) of an inch (15 mm) through 2 \( \frac{3}{8} \) inches (50 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 Copper or Copper Alloy Pipe and Tubing. Joints between copper 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 flaring 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. The second dimple shall be ⅛ 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. 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 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 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.

1211.4 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.

1211.5 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 listed or labeled 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.

1211.6 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.

1211.7 Polyethylene (PE) Plastic Pipe/Tubing. Joints between polyethylene (PE) plastic pipe, tubing, or fittings shall be installed in accordance with ASTM D2657 and one of the following heat fusion methods:

1. Butt-fusion joints shall be installed in accordance with ASTM D2657 and shall be installed in accordance with ASTM D2657 and shall be installed in accordance with ASTM D2657 and shall be installed in accordance with ASTM D2657. Lubricant recommended for the application by the pipe manufacturer shall be applied to the gasket and plain end of the pipe.

2. Electro-fusion joints shall be heated internally by a conductor at the interface of the joint made by embedding the resistance wire in the fitting and supplying with a heat source. Pipe shall be clamped in place and power applied through a controlled processor. The material surrounding the wire shall be melted along with the pipe and shall provide the pressure required for fusion. 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 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.

1211.8 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 ½ of an inch (3.2 mm) to ¼ of an inch (6.4 mm) from the end of the pipe. The jaws of the crimping tool shall be centered over the crimp ring and tool perpendicular to the barb. The jaws shall be closed around the crimp ring and shall not be crimped more than once.

2. Compression joints for PE-AL-PE pipe, 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.

1211.9 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.

1211.10 Polypropylene (PP) Pipe. Joints between cross-linked 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.

1211.11 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.

1211.12 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.

1211.13 Joints Between Various Materials. Joints between various materials shall be installed in accordance with the manufacturer’s installation instructions and shall comply with Section 1211.13.1 through Section 1211.13.2.

1211.13.1 Copper 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 brass copper alloy adapter, brass 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.

1211.13.2 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 Radiant Floor Heating Panels. Radiant floor heating panels shall be protected with a high-limit control set 20°F (11°C) above the maximum design water temperature for the panel to prevent the introduction of heat into the panel. The high-limit setting shall not exceed the temperature rating for the pipe and shall be equipped with a manual reset.

1213.3 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.

1213.3.1 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.

1213.4 Occupied Spaces. An air-temperature-sensing device shall be installed in the occupied space to regulate the operation of the heat-distribution system.

1213.5 Return-Water Low-Temperature Protection. Where a minimum return-water temperature to the heat source is specified, the heating system shall be designed and installed to ensure that the minimum return-water temperature is maintained during the normal operation of the heat source.

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 not be required. An external cut-off device shall be installed in accordance with the heat-source manufacturer’s installation instructions. No valve shall be located between the external low-water fuel cut-off and the heat-source unit. Where a pumped condensate return is installed, a second low-water cut-off shall be provided.

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 Water. Where an automatic makeup water 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.

1214.6 Air-Removal Device. Provision shall be made for the removal of air in the heat-distribution piping system. The air-removal device shall be located in the area of the heat-distribution piping system where air accumulates. Air-removal devices shall be installed to facilitate their removal for examination, repair, or replacement.

1214.7 Air-Separation Device. An air-separation device shall be installed on a closed heat-distribution system. The device shall be located in accordance with the manufacturer’s installation instructions or at the point in the heat-distribution system where there is no pressure change and the water in the heat-distribution system is at the highest temperature.

1214.8 Secondary Loops. Secondary loops that are isolated from the primary heat-distribution loop by a heat exchanger shall have an air-removal device or an air-separation device specified in accordance with Section 1214.6 or 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 heat-distribution units or other system 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 Medium. The flash point of a transfer fluid in a hydronic piping system shall be a minimum of 50°F (10°C) above the maximum system operating temperature. The transfer fluid shall be compatible with the makeup water 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 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 1/4 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. Steam traps shall be installed on pump and receiver condensate systems to eliminate negative pressures in coils and heat exchangers on a low-pressure steam system. Air vents shall not be used on a vacuum system.

1216.5 Condensate Flow. System piping shall be installed to allow condensate to flow from the steam trap to the condensate tank or steam boiler.

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 panels shall be installed in accordance with the system design.

1217.2 Radiant Under-Floor Heating. Floor surface temperatures shall not exceed the following temperatures:

1. 85°F (29°C) in dwellings, buildings, or structures.
2. 85°F (29°C) in occupancies where prolonged foot contact with the floor, and solid or laminated hardwood flooring.
3. 90°F (32°C) in bathrooms and indoor swimming pools.

The radiant heating panel temperature shall not exceed the maximum temperature rating of the materials used in the construction of the radiant heating panel. The radiant panel shall be protected with a high-limit control in accordance with Section 1213.2.

1217.3 Chilled Water Systems. Chilled water systems for cooling shall be designed to minimize the potential for condensation. Chilled water piping, valves, and fittings shall be insulated and vapor sealed to prevent surface condensation.

1217.4 Dehumidification. A chilled ceiling or chilled floor panels used for space cooling shall be installed in a humidity-controlled environment. An air handling device that removes humidity shall be incorporated into the system to keep the relative humidity below 70 percent. A humidity sensor shall be installed within the space to turn off the panels where the surface approaches the dew point.

1217.5 Tube Placement. Hydronic radiant panel tubing shall be installed in accordance with the manufacturer’s installation instructions and system design. The 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 1217.5. Actual loop lengths shall be determined by spacing, number of loops, 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.

In a single-zone multiple-manifold installation, balanced flow through manifolds shall be as specified in Section 1215.4.

### Table 1217.5

<table>
<thead>
<tr>
<th>Nominal Tube Size (inches)</th>
<th>Maximum Loop Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>125</td>
</tr>
<tr>
<td>3/8</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
1217.6 Poured Floor Systems (Thermal Mass). Where tubing is embedded in a 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. The top of the tubing shall be embedded in the slab not less than 2 inches (51 mm) below the surface.

1217.6.1 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 a protective pipe sleeve. The space between the tubing and sleeve shall be sealed. 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 expansion joint or the tubing shall be installed below the slab.

1217.6.2 Insulation. Where a poured concrete radiant floor system is installed in contact with the soil, not less than R-5 insulation shall be installed and shall be placed between the soil and the concrete; extend to the outside edges of the concrete; and be placed on all slab edges.

Where a poured concrete radiant floor system is installed on grade, not less than R-5 insulation shall be installed and placed on vertical slab edges.

Where a poured concrete radiant floor system is installed within a habitable space above and below, the total R-value of the floor system below the concrete slab shall be more than the total R-value of the material lying above the concrete slab and the floor system shall have not less than a R-3 value.

1217.6.3 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.

An air space of not less than 2 inches (51 mm) shall be maintained between the top of the insulation and the underside of the floor unless a conductive plate is installed. Where tubing is installed above or in the subfloor and not embedded in concrete, the floor assembly shall be insulated with not less than R-12 material below the tubing.

1217.6.4 Wall and Ceiling Panels. Where piping is installed in the wall stud 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 2 inches (51 mm) shall be maintained between the insulation and the interior surface of the panel unless a conductive plate is installed.

1217.7 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.

1217.7.1 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.

1217.7.2 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 expansion screws of sufficient size and anchorage to support the loads applied. In high moisture areas, 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 Systems.

1220.1 General. Additional heating loads shall be sized in accordance with one of the following methods and the required additional capacity shall be added to the primary heat source.

1) Methods included in this chapter.
2) Other approved engineering methods acceptable to the Authority Having Jurisdiction.
3) Sizing guidelines included in the manufacturer’s instructions.

Where an auxiliary system is deemed to be in use only in seasons other than winter, it shall not be required to be combined with the space heating requirement in the winter. The heat source shall be sized to the level of the highest total seasonal load.

1220.2 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.

1220.3 Snow Melt. An automatic thermostatically operating control device that controls the supply hydronic solution temperature to the snow melt area shall be installed in the system. A means shall be provided to prevent low return hydronic solution temperature, as specified in Section 1213.5. Snow melt auxiliary systems shall be protected from freezing with an approved hydronic solution. The circulating heat transfer fluid shall be a mixture of propylene glycol or ethylene glycol, and water. Automotive antifreeze shall not be used.

1220.3.1 Tube Placement. Snow melt tubing shall be installed in accordance with the manufacturer’s installation instructions and with the tubing layout and spacing as specified in the system design. Except for distribution mains, tube spacing that is shown in the design as center-to-center and the individual loop lengths shall be installed with a variance of not more than ±10 percent from the design.

The length of continuous tubing from a supply-and-return manifold arrangement shall not exceed the lengths specified by the manufacturer’s installation instructions and system design or, in the absence of manufacturer’s specifications, the lengths specified in Table 1220.3.1. Actual loop lengths shall be determined by spacing, flow rate, temperature, and pressure drop, as specified in the system design.

### TABLE 1220.3.1

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

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.

1220.3.2 Poured Concrete Slab Systems (Thermal Mass). Where tubes are embedded in a 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. The top of the tubing shall be embedded in the slab not less than 2 inches (51 mm) below the surface.

1220.3.3 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 a protective pipe sleeve. The space between the tubing and sleeve shall be sealed. The tubing at the location of a 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.

1220.3.4 Concrete Slab Preparation. A solid foundation shall be prepared before the tubing is installed. Compaction shall be used for slabs, sidewalks, and driveways.

1220.3.5 Insulation. Where a poured concrete snow melt system is installed in contact with the soil, insulation that has a R-5 value shall be placed between the concrete and the compacted grade; extend 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.

1220.3.6 Testing. Testing of auxiliary systems shall be in accordance with Section 1205.2.
1220.4 Hydronic Makeup Air Units. Hydronic makeup air units that are affected by freezing shall be protected against freezing by a hydronic solution or a method approved by the Authority Having Jurisdiction.

1221.0 Piping Installation.
1221.1 General. Piping, fittings, and connections shall be installed in accordance with the conditions of their approval.

1221.2 Embedded Piping and Joints. Piping for heating or cooling panels 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 plaster 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 Tested. Piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During the pour, the pipe shall maintain the test pressure of not less than one and one-half times the operating pressure but 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.  
1302.1 Installation 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), other than service pipe. Fuel oil piping systems shall be installed in accordance with NFPA 31.

1301.1 Applicability.  Coverage of piping systems shall extend from the point of delivery to the appliance connections. For other than undiluted liquefied petroleum 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 liquefied petroleum gas systems, the point of delivery shall be considered the outlet of the final pressure regulator, exclusive of the 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)]

1302.0 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 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 liquefied petroleum gas systems, the point of delivery shall be considered the outlet of the final pressure regulator, exclusive of the 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.  Piping systems requirements shall include design, materials, components, fabrics, assembly, installation, testing, inspection, operation, and maintenance. [NFPA 54:1.1.1.1(C)]

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

1. Portable LP-Gas appliances and equipment 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 are 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. [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 1316.1. Test gauges used in conducting tests shall be in accordance with Section 1303.3.3.

1303.3.3 Test Gauges. Tests required by this code, which are performed utilizing dial gauges, shall be limited to gauges having the following pressure graduations or incrementations.
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) incrementation 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) incrementation or less.

1303.3.3 Pressure Tests (exceeding 100 psi). Required pressure tests exceeding 100 psi (689 kPa) shall be performed with gauges incremented for 2 percent 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. Where upon 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, 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 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. This 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. Where additional appliances are being connected to a gas piping system, the existing piping shall be checked to determine whether it has adequate capacity. Where inadequate, the existing system shall be enlarged as required, or separate gas piping of approved capacity shall be provided. [NFPA 54:5.1.2]

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. 1308.3.1 Interconnections Supplying Separate Users. 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]

1308.3.21 Interconnections for Standby Fuels. Where a supplementary gas for standby use is connected
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 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 (in cubic feet per hour) shall be calculated using the manufacturer’s input ratings of the appliance served, adjusted for altitude. 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 the 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]

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 instructions. [NFPA 54:5.4.3]

1308.4.3 Allowable Pressure Drop. The design pressure loss in a 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 be in accordance with the requirements of this chapter or shall be acceptable to the Authority Having Jurisdiction. [NFPA 54:5.6.1.1]

1308.5.1 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 approved 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 be investigated and tested to determine that it is safe and approved for the proposed service and, in addition, shall be recommended for that service by the manufacturer and shall be acceptable to the Authority Having Jurisdiction. [NFPA 54:5.6.1.3]

1308.5.2 Metallic Pipe. 1308.5.2.1 Cast-Iron. Cast-iron pipe shall not be used. [NFPA 54:5.6.2.1]

1308.5.2.2 Steel and Wrought-Iron. Steel and wrought-iron pipe shall be not less than standard weight (Schedule 40) and shall comply with one of the following standards:

(1) ASME B36.10
(2) ASTM A53
(3) ASTM A106 [NFPA 54:5.6.2.2]

1308.5.2.3 Copper and Brass Copper Alloy. Copper and brass copper alloy pipe shall not be used where the gas contains more than an average of 0.3

<table>
<thead>
<tr>
<th>APPLIANCE</th>
<th>INPUT (Btu/h approx.)</th>
</tr>
</thead>
<tbody>
<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></td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60 000</td>
</tr>
<tr>
<td>Hydronic boiler</td>
<td></td>
</tr>
<tr>
<td>Single family</td>
<td>100 000</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>Hydronic boiler</td>
<td></td>
</tr>
<tr>
<td>Single family</td>
<td>120 000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>75 000</td>
</tr>
<tr>
<td>Water Heating Appliances</td>
<td></td>
</tr>
<tr>
<td>Water heater, automatic storage</td>
<td></td>
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<tr>
<td>30 to 40 gallon tank</td>
<td>35 000</td>
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<tr>
<td>Water heater, automatic storage</td>
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</tr>
<tr>
<td>50 gallon tank</td>
<td>50 000</td>
</tr>
<tr>
<td>Water heater, automatic instantaneous</td>
<td></td>
</tr>
<tr>
<td>Capacity at 2 gallons per minute</td>
<td>142 800</td>
</tr>
<tr>
<td>Capacity at 4 gallons per minute</td>
<td>285 000</td>
</tr>
<tr>
<td>Capacity at 6 gallons per minute</td>
<td>428 400</td>
</tr>
<tr>
<td>Water heater, domestic, circulating or</td>
<td></td>
</tr>
<tr>
<td>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). [NFPA 54:5.6.2.3]

Threaded copper, brass, copper alloy, or aluminum alloy pipe shall not be used with gases corrosive to such material. [NFPA 54:5.6.2.4]

1308.5.2.43 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, insulation, or is subject to repeated wettings by such liquids as water, detergents, or sewage. [NFPA 54:5.6.2.5]

1308.5.3 Metallic Tubing. Seamless copper, aluminum alloy, or steel tubing shall not be used with gases corrosive to such material. [NFPA 54:5.6.3]

1308.5.3.1 Steel. Steel tubing shall comply with ASTM A254. [NFPA 54:5.6.3.1]

1308.5.3.2 Copper and Brass Copper Alloy. Copper and brass 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. [NFPA 54:5.6.3.2]

1308.5.3.3 Aluminum Alloy. 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 54:5.6.3.3]

1308.5.3.4 Corrugated Stainless Steel. 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 be in accordance with ASTM D2513. Plastic pipe, tubing, and fittings, other than polyethylene, shall be identified and be in accordance with ASTM D2513-2009. Pipe to be used shall be marked “gas” and “ASTM D2513.” [NFPA 54:5.6.4.1.1, 5.6.4.1.2]

1308.5.5 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]

1308.5.6 Anodeless Risers. Anodeless risers shall comply with Section 1308.5.6.1 through 1308.5.6.3. [NFPA 54:5.6.4.3]

1308.5.6.1 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)]

1308.5.6.2 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)]

1308.5.6.3 Undiluted Liquefied Petroleum Gas Piping. The use of plastic pipe, tubing, and fittings in undiluted liquefied petroleum gas piping systems shall be in accordance with NFPA 58. [NFPA 54:5.6.4.3(3)]

1308.5.7 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]

1308.5.8 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]

1308.5.9 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]

1308.5.9.1 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]

1308.5.9.2 Number of Threads. Field threading of metallic pipe shall be in accordance with Table 1308.5.9.2. [NFPA 54:5.6.7.3]

### TABLE 1308.5.9.2

**SPECIFICATIONS FOR THREADING METALLIC PIPE**

<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>1¼</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>1½</td>
<td>1</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
1308.5.9.3 Thread Joint Compounds. Thread joint compounds shall be resistant to the action of liquefied petroleum gas or to other chemical constituents of the gases to be conducted through the piping. [NFPA 54:5.6.7.4]

1308.5.10 Metallic Piping Joints and Fittings. The type of piping joint used shall be approved for the pressure-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 additional forces due to temperature expansion or contraction, vibration, fatigue, or the weight of the pipe and its contents. [NFPA 54:5.6.8]

1308.5.10.1 Pipe Joints. Pipe joints shall be threaded, flanged, brazed, or 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. [NFPA 54:5.6.8.1]

1308.5.10.2 Tubing Joints. Tubing joints shall either be made with approved gas tubing fittings, 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. Brazing alloys shall not contain more than 0.05 percent phosphorus. [NFPA 54:5.6.8.2]

1308.5.10.3 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 for the conditions and where provisions are made in the design to prevent separation of the joints. [NFPA 54:5.6.8.3]

1308.5.10.4 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 or wrought-iron pipe shall be 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. [NFPA 54:5.6.8.4]

1308.5.11 Plastic Piping, Joints, and Fittings. Plastic pipe, tubing, and fittings shall be installed in accordance with the manufacturer’s installation instructions. Section 1308.5.11.1 through Section 1308.5.11.4 shall be observed where making such joints. [NFPA 54:5.6.9]

1308.5.11.1 Joint Design. The joint shall be designed and installed so that the longitudinal pullout resistance of the joint shall be equal to the tensile strength of the plastic piping material. [NFPA 54:5.6.9(1)]

1308.5.11.2 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 D 2513.” [NFPA 54:5.6.9(2)]

1308.5.11.3 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)]

1308.5.11.4 Liquefied Petroleum Gas Piping Systems. Plastic piping joints and fittings for use in liquefied petroleum gas-piping systems shall be in accordance with NFPA 58. [NFPA 54:5.6.9(4)]
1308.5.12 Flanges. Flanges shall comply with ASME B16.1, ASME B16.20, or MSS SP-6. The pressure-temperature ratings shall equal or exceed that required by the application. [NFPA 54:5.6.10]

1308.5.12.1 Flange Facings. Standard 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 54:5.6.10.1]

1308.5.12.2 Lapped Flanges. Lapped flanges shall be used aboveground or in exposed locations accessible for inspection. [NFPA 54:5.6.10.2]

1308.5.13 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] Flange gaskets shall comply with the following requirements:

(1) Acceptable materials include the following:
   (a) Metal (plain or corrugated)
   (b) Composition
   (c) Aluminum “O” rings and spiral-wound metal gaskets [NFPA 54:5.6.11.1]

(2) Where a flanged joint is opened, the gasket shall be replaced. [NFPA 54:5.6.11.2]

(3) Full-face gaskets shall be used with bronze and cast-iron flanges. [NFPA 54:5.6.11.3]

1308.6 Gas Meters. Gas meters shall be selected for the maximum expected pressure and permissible pressure drop. [NFPA 54:5.7.1]

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 coal bins, 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. Meters shall not be located 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 attached by the installing agency, designating the building or the part of the building being supplied. [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 exceeds that at which the branch supply line or appliances are designed to operate or vary beyond design pressure limits. [NFPA 54:5.8.1]

1308.7.1 Overpressure Protection. Where the gas supply design pressure in piping systems located indoors exceeds 2 psi (14 kPa) and line pressure regulators are installed to reduce the supply pressure to 14 inches water column (3.5 kPa) or less, the following shall apply:

(1) Regulators shall be provided with factory installed overpressure protection devices.

(2) Overpressure protection devices shall limit the pressure downstream of the line pressure regulator to 2 psi (14 kPa) in the event of failure of the line pressure regulator. [NFPA 54:5.8.3]

1308.7.2 Listing. Line pressure regulators shall be listed in accordance with CSA Z21.80. [NFPA 54:5.8.2]

1308.7.3 Location. The gas pressure regulator shall be accessible for servicing. [NFPA 54:5.8.3]

1308.7.4 Regulator Protection. Pressure regulators shall be protected against physical damage. [NFPA 54:5.8.4]

1308.7.5 Venting. 1308.7.5.1 Line Pressure Regulators. Line pressure regulators shall comply with 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 where approved by the Authority Having Jurisdiction, the vent lines shall be permitted to be manifolded in accordance with accepted engineering practices to minimize back-pressure in the event of diaphragm failure. (See Section 1308.7.5.22 for information on properly locating the vent.) Materials for vent piping shall comply with Section 1308.5.

Exception: A regulator and vent limiting means combination listed in accordance 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 will cause blockage.
(3) The regulator vent shall terminate not less than 3 feet (914 mm) from a source of ignition.
(4) At locations where regulators will 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 Venting of Gas Appliance Pressure Regulators. Venting of gas appliance pressure regulators shall be in accordance with Section 1310.0. [NFPA 54:5.8.5.2]

1308.7.1 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]

1308.9 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]

1308.10 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]

1308.11 Expansion and Flexibility. Piping systems shall be designed to prevent failure from thermal expansion or contraction. [NFPA 54:5.14.1]

1308.11.1 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, sized, and installed in accordance with the manufacturer’s installation instructions. [NFPA 54:5.13]

1310.0 Venting of Gas Appliance Pressure Regulators. 1310.1 General. Venting of gas appliance pressure regulators shall be in accordance 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, where 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.
(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 will be readily ignited by the pilot and the heat liberated thereby will not adversely affect the normal operation of the safety shutoff.
system. The terminus of the vent shall be securely held in a fixed position relative to the pilot. For manufactured gas, the need for a flame arrester in the vent piping shall be determined.

(6) Vent lines from an appliance pressure regulator and bleed lines 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 54:9.1.19]

1311.0 Gas Piping Installation.
1311.1 Piping Underground. Underground gas piping shall be installed with approved clearance from other underground structures 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 clearance or shall be insulated from sources of heat so as to prevent the heat from impairing the serviceability of the pipe. [NFPA 54:7.1.1]

1311.1.1 Cover Requirements. Underground piping systems shall be installed with a cover not less than 12 inches (305 mm). Where external damage to the pipe or tubing from external forces is likely to result, the cover shall be not less than 18 inches (457 mm). Where a cover not less than 12 inches (305 mm) cannot be provided, the pipe shall be installed in conduit or bridged (shielded). [NFPA 54:7.1.2.1]

1311.1.2 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]

1311.1.2.1 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]

1311.1.3 Protection Against Corrosion. Gas piping in contact with earth or other material that is capable of corroding the piping shall be protected against corrosion in an approved manner. Where dissimilar metals are joined underground, an insulating coupling or fitting shall be used. Piping shall not be laid in contact with cinders. Uncoated threaded or socket-welded joints shall not be used in piping in contact with soil or where internal or external crevice corrosion is known to occur. [NFPA 54:7.1.3]

1311.1.4 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]

1311.1.5 Piping through Foundation Wall. Underground piping 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 and between the sleeve and the wall shall be sealed to prevent entry of gas and water. [NFPA 54:7.1.5]

1311.1.6 Piping Underground Beneath Buildings. Where gas piping is installed underground beneath buildings, the piping shall be one of the following:

1. Encased in an approved conduit designed to withstand the imposed loads and installed in accordance with Section 1311.1.6.1 or Section 1311.1.6.2.

2. A piping or encasement system listed for installation beneath buildings. [NFPA 54:7.1.6]

1311.1.6.1 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 a gas leakage. Where the end sealing is of a type that will retain the full pressure of the pipe, the conduit shall be designed for the same pressure as the pipe. The conduit shall extend not less than 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]

1311.1.6.2 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]

1311.1.7 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]

1311.1.7.1 Connections Between Metallic and Plastic Piping. Connections made between metallic and plastic piping shall be made with fittings that are in accordance with one of the following:

1. ASTM D2513

2. ASTM F1973

3. ASTM F2509 [NFPA 54:7.1.7.2]

1311.1.7.2 Tracer Wire. 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 of the tracer wire or tape shall be brought aboveground at a building wall or riser. [NFPA 54:7.1.7.3]

1311.2 Installation of 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 against 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]

1311.2.1 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 beams or joists are cut or notched. [NFPA 54:7.2.2]

1311.2.2 Gas Piping to be Sloped. Piping for other than dry gas conditions shall be sloped not less than 1⁄4 inch in 15 feet (1.4 mm/m) to prevent traps. [NFPA 54:7.2.4]

1311.2.2.1 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.

1311.2.3 Aluminum Alloy Pipe. Aluminum alloy pipe shall not be used in exterior locations or underground. [NFPA 54:5.6.2.6]

1311.2.4 Prohibited Locations. Gas piping inside a 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 54:7.2.5]

Exception: Ducts used to provide ventilation air in accordance with Section 701.0 or to above-ceiling spaces in accordance with Section 1311.2.2.1.

1311.2.5 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 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 comply with the requirements of MSS SP-58. [NFPA 54:7.2.6.1]

1311.2.5.1 Spacing. Spacing of supports in gas piping installations shall not exceed the distance shown in Table 1311.2.5.1. Spacing of supports for CSST shall be in accordance with the CSST manufacturer’s instruction. [NFPA 54:7.2.6.2]

1311.2.5.2 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. Parts of the supporting system shall be designed and installed so they are not disengaged by movement of the supported piping. [NFPA 54:7.2.6.3]

1311.2.6 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. [NFPA 54:7.2.6]

1311.3 Concealed Piping in Buildings. Gas piping in concealed locations shall be installed in accordance with this section. [NFPA 54:7.3.1]

1311.3.1 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 1308.5.10.2). [NFPA 54:7.3.2(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. [NFPA 54:7.3.2(3)]

(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.

1311.3.2 Piping in Partitions. Concealed gas piping shall not be located in solid partitions. [NFPA 54:7.3.3]

1311.3.3 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 be in accordance with the following requirements:

(1) A steel striker barrier not less than 0.0508 of an inch (1.3 mm) thick, or equivalent, shall be installed between the tubing and the finished wall and extend
not less than 4 inches (102 mm) beyond concealed penetrations of plates, firestops, wall studs, and similar construction features.

(2) The tubing shall be installed in single runs and shall not be rigidly secured. [NFPA 54:7.3.4]

1311.3.4 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 minimum damage to the building. Where piping in floor channels is 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 not less than 11/2 inches (38 mm) of concrete and shall not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Piping, fittings, and risers shall be protected against corrosion in accordance with Section 1308.5.8. Piping shall not be embedded in concrete slabs containing quick-set additives or cinder aggregate. [NFPA 54:7.3.5.2]

1311.4 Piping in Vertical Chases. Where gas piping exceeding 5 psi (34 kPa) is located within vertical chases in accordance with Section 1311.5(2), the requirements of Section 1311.4.1 through Section 1311.4.3 shall apply. [NFPA 54:7.4]

1311.4.1 Pressure Reduction. Where pressure reduction is required in branch connections in accordance with Section 1311.5, such reduction shall take place either inside the chase or immediately adjacent to the outside wall of the chase. Regulator venting and downstream over-pressure protection shall comply with Section 1308.7.1 and Section 1308.7.5. 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 directly to the outdoors. [NFPA 54:7.4.1]

1311.4.2 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]

1311.4.3 Ventilation. A chase shall be ventilated to the outdoors and at the top. The opening(s) shall have a minimum free area [in square inches (m²)] equal to the product of one-half of the maximum pressure in the piping [in psi (kPa)] times the largest nominal diameter of that piping [in inches (mm)], 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]

1311.5 Maximum Design Operating Pressure. The maximum design operating pressure for 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 welded.

(2) The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation. (3) 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 equipment rooms

(4) The piping is a temporary installation for building under construction. (5) The piping serves appliances or equipment used for agricultural purposes.

(6) The piping system is an LP-Gas piping system with a design operating pressure exceeding 20 psi (138 kPa) and in accordance with NFPA 58. LP-Gas systems designed to operate below -5°F (-21°C) or with butane or a propane-butane mix shall be designed to either accommodate liquid LP-Gas or to prevent LP-Gas vapor from condensing back into liquid. [NFPA 54:5.5]

1311.6 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]

1311.6.1 Metallic Pipe. Metallic pipe bends shall comply with the following:

(1) Bends shall be made with bending equipment and procedures intended for that purpose.

(2) 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) The pipe shall not be bent through an arc of more than 90 degrees (1.57 rad).

(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]

1311.6.2 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 be not less than 25 times the inside diameter of the pipe.

(4) Where the piping manufacturer specifies the use of special bending equipment or procedures, such equipment or procedures shall be used. [NFPA 54:7.5.2]
1311.6.3 Elbows. Factory-made welding elbows or transverse segments cut therefrom shall have an arc length measured along the crotch of not less than 1 inch (25.4 mm) for pipe sizes 2 inches (50 mm) and larger. [NFPA 54:7.5.3]

1311.7 Drips and Sediment Traps. 1311.7.1 Provide Drips where Necessary. For other than dry gas conditions, a drip shall be provided at a point in the line of pipe where condensate is capable of collecting. 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 so installed as to constitute a trap wherein an accumulation of condensate will shut off the flow of gas before it will run back into the meter. [NFPA 54:7.6.1]

1311.7.2 Location of Drips. Drips shall be installed in such locations that they will be 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]

1311.7.3 Sediment Traps. The installation of sediment traps shall comply with Section 1312.7. [NFPA 54:7.6.3]

1311.8 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 1311.8(4) and Section 1311.8(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]

1311.8.1 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. Where 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 1312.2.1 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]

1311.8.1.1 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]

1311.9 Branch Pipe Connection. Where 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]

1311.10 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]

1311.10.1 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 are readily identified. [NFPA 54:7.9.2.1]

1311.10.1.1 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 54:7.9.2.2]

1311.10.2 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 54:7.9.2.3]

1311.10.3 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 such gas outlets are supplied. The shutoff valve shall be accessible and shall be located within the laboratory or located adjacent to the laboratory’s egress door and shall be identified. [NFPA 54:7.9.2.4]

1311.11 Prohibited Devices. No device shall be placed inside the gas piping or fittings that will reduce the cross-sectional area or otherwise obstruct the free flow of gas, except where an allowance in the piping system design has been made for such a device and where approved by the Authority Having Jurisdiction. [NFPA 54:7.10]

1311.12 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 54:7.11]

1311.13 Systems Containing Flammable Gas-Air Mixtures. Systems containing flammable gas-air mixtures shall be in accordance with Section 1311.13.1 through Section 1311.13.6.

1311.13.1 Required Components. A central premix system with a flammable mixture in the blower or compressor shall consist of the following components:

(1) A gas-mixing machine in the form of an automatic gas-air proportioning device combined with a downstream blower or compressor.

(2) Flammable mixture piping, not less than Schedule 40 NPS.

(3) Automatic firecheck(s).

(4) Safety blowout(s) or backfire preventers for systems utilizing flammable mixture lines above 2½ inches (65 mm) nominal pipe size (NPS) or the equivalent. [NFPA 54:7.12.1]

1311.13.2 Optional Components. The following components shall also be permitted to be utilized in a type of central premix system:

(1) Flowmeter(s)

(2) Flame arrester(s) [NFPA 54:7.12.2]

1311.13.3 Additional Requirements. Gas-mixing machines shall have nonsparking blowers and shall be so constructed that a flashback will not rupture machine casings. [NFPA 54:7.12.3]

1311.13.4 Special Requirements for Mixing Blowers. A mixing blower system shall be limited to applications with minimum practical lengths of mixture piping, limited to a mixture pressure of not more than 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 so arranged 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]

1311.13.5 Installation of Gas-Mixing Machines. Installation of gas-mixing machines shall comply with the following:

(1) The machine shall be located in a large, well-ventilated area or in a small detached building or cutoff room provided with room construction and explosion vents in accordance with sound engineering principles. Such rooms or below finished grade installations shall have approved 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.

(3) Air intakes for gas-mixing machines using compressors or blowers shall be taken from outdoors where 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, the controls shall be interlocked so that the blower or compressor will stop 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 these effects of downstream pulsation and equipment overload shall be prepared and utilized as needed. [NFPA 54:7.12.5]

1311.13.6 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 practicable to the burner inlets in accordance with the firecheck manufacturer’s installation instructions.

(2) A separate manually operated gas valve shall be provided at each automatic firecheck for shutting off the flow of 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 to prevent reignition 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 more 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 installation instructions shall be followed where 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 toward 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 a 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 gas-air mixture in the event of rupture. [NFPA 54:7.12.6]

1311.14 Electrical Bonding and Grounding.

1311.14.1 Pipe and Tubing other than CSST. Each aboveground 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 where it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance. [NFPA 54:7.13.1]

1311.14.2 Bonding of CSST Gas Piping. CSST gas piping systems shall be bonded to the electrical service grounding electrode system. The bonding jumper shall connect to a metallic pipe or fitting between the point of delivery and the first downstream CSST fitting. The bonding jumper shall be not smaller than 6 AWG copper wire or equivalent. Gas piping systems that contain one or more segments of CSST shall be bonded in accordance with this section. [NFPA 54:7.13.2]

1311.14.3 Grounding Conductor of Electrode. Gas piping shall not be used as a grounding conductor or electrode. [NFPA 54:7.13.3]

1311.14.4 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]

1311.15 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]

1311.16 Electrical Connections. Electrical connections between wiring and electrically operated control devices in a piping system shall comply with the requirements of NFPA 70. [NFPA 54:7.15.1]

1311.16.1 Safety Control. An essential safety control depending on electric current as the operating medium shall be of a type that will shut off (fail safe) the flow of gas in the event of current failure. [NFPA 54:7.15.2]

1312.0 Appliance Connections to Building Piping.

1312.1 Connecting Gas Appliances. Appliances shall be connected to the building piping in accordance with Section 1312.4 through Section 1312.6 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 accordance 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. One connector shall be used for each appliance. (4) A listed connector in accordance with CSA Z21.75. One connector shall be used for each appliance.

(5) CSST where installed in accordance with the manufacturer’s installation instructions.

(6) Listed nonmetallic gas hose connectors in accordance with Section 1312.2.

(7) In Section 1312.1(2) through Section 1312.1(6), the connector or tubing shall be installed so as to be protected against physical and thermal damage. Aluminum alloy tubing and connectors shall be coated to protect against external corrosion where they are in contact with masonry, plaster, or insulation, or are subject to repeated wettings by such liquids as water (except rainwater), detergents, or sewage. Connectors and tubing shall not be installed through an opening in an appliance housing, cabinet, or casing, unless the tubing or connector is protected against damage. [NFPA 54:9.6.1]

1312.1.1 Commercial Cooking Appliances. Commercial cooking appliances that are moved for cleaning and sanitation purposes shall be connected in accordance with the connector manufacturer’s installation instructions using a listed appliance connector in accordance with CSA Z21.69. The commercial cooking appliance connector installation shall be configured in accordance with the manufacturer’s installation instructions. [NFPA 54:9.6.1.1]

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 54:9.6.1.2]

1312.2 Use of Gas Hose Connectors. Listed gas hose connectors shall be installed in accordance with the manufacturer’s installation instructions and in accordance with Section 1312.2.1 and Section 1312.2.2. [NFPA 54:9.6.2]

1312.2.1 Indoor. Indoor gas hose connectors shall be used to connect laboratory, shop, and ironing appliances or equipment requiring mobility during operation. An appliances or equipment shutoff valve shall be installed where the connector is attached to the building piping. The connector shall be of minimum length and shall not exceed 6 feet (1829 mm). The connector shall not be concealed and shall not extend from one room to another or pass through wall partitions, ceilings, or floors.
1312.2.2 Outdoor. Where outdoor gas hose connectors are used to connect portable outdoor appliances, the connector shall be listed in accordance with CSA Z21.54. 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 to prevent the accumulation of water or foreign matter. This connection shall be made in the outdoor area where the appliance is to be used. [NFPA 54:9.6.2(2)].

The connector length shall not exceed 15 feet (4572 mm).

1312.3 Connection of Portable and Mobile Industrial Appliances. 1312.3.1 Flexible Hose. 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 approved and safe for the conditions under which it is used. [NFPA 54:9.6.3.1]

1312.3.21 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 approved for the service required, and the minimum number required shall be installed. [NFPA 54:9.6.3.2]

1312.3.32 Metal Flexible Connectors. Where industrial appliances subject to vibration are connected to the building piping system by the use of metal flexible connectors, the connectors shall be approved for the service required. [NFPA 54:9.6.3.3]

1312.3.43 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 walls, partitions, ceilings, or floors. Flexible connections shall not be used in a 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 54:9.6.3.4]

1312.4 Appliance Shutoff Valves and Connections. Appliances 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 and shall be installed 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 where listed for such use. [NFPA 54:9.6.4.1]

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.

1312.5 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 54:9.6.5]

1312.6 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 54:9.6.6]

1312.7 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 1312.7 or other device recognized as an effective sediment trap. Illuminating appliances, ranges, clothes dryers, decorative appliances for installation in vented fireplaces, gas fireplaces, and outdoor grills shall not be required to be so equipped.

![FIGURE 1312.7](image-url)

For SI units: 1 inch = 25.4 mm
1312.8 Installation of Piping. Piping shall be installed in a manner not to interfere with inspection, maintenance, or servicing of the appliance. [NFPA 54:9.6.8]

1313.0 Appliance Overpressure Protection.
1313.1 General. The maximum operating pressure for piping systems serving appliances designed to operate at 14 inches water column (3.5 kPa) inlet pressure or less shall be 2 pounds-force per square inch gauge (psig) (14 kPa) unless an over pressure protection device designed to limit pressure at the appliance to 2 psig (14 kPa) upon failure of the line gas pressure regulator is installed.

1314.0 Safety Shutoff Devices for Unlisted LP-Gas Appliance Used Indoors.
1314.1 General. Unlisted appliances for use with undiluted liquefied petroleum 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]

1315.0 Liquefied Petroleum Gas Facilities and Piping.
1315.1 General. Liquefied petroleum gas facilities shall comply with NFPA 58.

1316.0 Pressure Testing and Inspection.
1316.1 Piping Installations. Prior to acceptance and initial operation, piping installations shall be visually inspected and pressure-tested to determine that the materials, design, fabrication, and installation practices are in accordance with the requirements of this code. [NFPA 54:8.1.1.1]

1316.2 Inspection Requirements. Inspection shall consist of visual examination during or after manufacture, fabrication, assembly, or pressure tests. [NFPA 54:8.1.1.2]

1316.3 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]

1316.4 New Branches. Where new branches are installed to new appliances, the newly installed branches 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]

1316.5 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 two valves are installed in series with a valved "telltale" located between these valves. A valve shall not be subjected to the test pressure unless it is determined that the valve, including the valve-closing mechanism, is designed to safely withstand the pressure. [NFPA 54:8.1.1.5]

1316.6 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]

1316.7 Test Medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas. OXYGEN SHALL NEVER BE USED. [NFPA 54:8.1.2]

1316.8 Test Preparation. Test preparation shall comply with Section 1316.8.1 through Section 1316.8.6.

1316.8.1 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]

1316.8.2 Expansion Joints. Expansion joints shall be provided with temporary restraints, where required, for the additional thrust load under test. [NFPA 54:8.1.3.2]

1316.8.3 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]

1316.8.4 Designed for (less than) Operating Pressures. 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]

1316.8.5 Designed for (equal to or more than) Operating Pressures. Where the piping system is connected to appliances or equipment designed for operating pressures equal to or greater than the test pressure, such appliances and equipment shall be isolated from the piping system by closing the individual appliance shutoff valve(s). [NFPA 54:8.1.3.5]

1316.8.6 Safety. 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]

1316.9 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. These tests shall be made in the presence of the Authority Having Jurisdiction. Necessary apparatus for conducting tests shall be furnished by the permit holder.

### 1316.10 Detection of Leaks and Defects.

The piping system shall withstand the test pressure specified without showing evidence of leakage or other defects. Reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction is readily attributed to some other cause. [NFPA 54:8.1.5.1]

#### 1316.10.1 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. Matches, candles, open flames, or other methods that provide a source of ignition shall not be used. [NFPA 54:8.1.5.2]

#### 1316.10.2 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]

### 1316.11 Piping System Leak Test.

Leak checks using fuel gas shall be permitted in piping systems that have been pressure-tested in accordance with Section 1316.0. [NFPA 54:8.2.1]

#### 1316.11.1 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 valves at unused outlets are closed and plugged or capped. [NFPA 54:8.2.2]

#### 1316.11.2 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]

#### 1316.11.3 Placing Appliances and Equipment in Operation.

Appliances and equipment shall not be placed in operation until after the piping system has been checked in accordance with Section 1316.11.2; connections to the appliance are checked for leakage; and purged in accordance with Section 1316.12. [NFPA 54:8.2.4]

### 1316.12 Purging Requirements.

The purging of piping shall be in accordance with Section 1316.12.1 through Section 1316.12.3. [NFPA 54:8.3]

#### 1316.12.1 Piping Systems Required to be Purged Outdoors.

The purging of piping systems shall be in accordance with the provisions of Section 1316.12.1.1 through Section 1316.12.1.4 where the piping system meets either of the following:

1. The design operating gas pressure exceeds 2 psig (14 kPa).
2. The piping being purged contains one or more sections of pipe or tubing meeting the size and length criteria of Table 1316.12.1. [NFPA 54:8.3.1]

### Table 1316.12.1

<table>
<thead>
<tr>
<th>Nominal Piping Size (inches)</th>
<th>Length of Piping (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 2½ &lt; 3</td>
<td>&gt; 50</td>
</tr>
<tr>
<td>≥ 3 &lt; 4</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>≥ 4 &lt; 6</td>
<td>&gt; 15</td>
</tr>
<tr>
<td>≥ 6 &lt; 8</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>≥ 8</td>
<td>Any length</td>
</tr>
</tbody>
</table>

For SI units: 1 inch = 25 mm; 1 foot = 304.8 mm

*CSST EHD size of 62 is equivalent to nominal 2 inches (50 mm) pipe or tubing size.

#### 1316.12.1.1 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 1316.12.1.3. Where gas piping meeting the criteria of Table 1316.12.1 is removed from service, the residual fuel gas in the piping shall be displaced with an inert gas. [NFPA 54:8.3.1.1]

#### 1316.12.1.2 Placing in Operation.

Where gas piping containing air and meeting the criteria of Table 1316.12.1 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 1316.12.1.3. [NFPA 54:8.3.1.2]

#### 1316.12.1.3 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 the following requirements:

1. The point of discharge shall be controlled with a shutoff valve.
2. The point of discharge shall be located not less than 10 feet (3048 mm) from sources of ignition, not less than 10 feet (3048 mm) from building openings, and not less than 25 feet (7620 mm) from mechanical air intake openings.
3. During discharge, the open point of discharge shall be continuously attended and monitored with a combustible gas indicator that is in accordance with Section 1316.12.1.4.
4. Purging operations introducing fuel gas shall be stopped where 90 percent fuel gas by volume is detected within the pipe.
5. Persons not involved in the purging operations shall be evacuated from areas within 10 feet (3048 mm) of the point of discharge. [NFPA 54:8.3.1.3]

#### 1316.12.1.4 Combustible Gas Indicator.

Combustible gas indicators shall be listed and shall be calibrated in accordance with the manufacturer’s instructions. Combustible gas indicators shall numerically display a volume scale from 0 percent to 100 percent in 1 percent or smaller increments. [NFPA 54:8.3.1.4]
1316.12.2 Piping Systems Allowed to be Purged Indoors or Outdoors. The purging of piping systems shall be in accordance with the provisions of Section 1316.12.2.1 where the piping system meets both of the following:

1. The design operating pressure is 2 psig (14 kPa) or less.
2. The piping being purged is constructed entirely from pipe or tubing not meeting the size and length criteria of Table 1316.12.1. [NFPA 54:8.3.2]

1316.12.2.1 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 discharge to the indoors or outdoors, and the point of discharge shall be monitored with a listed combustible gas detector in accordance with Section 1316.12.2.2. Purging shall be stopped where 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]

1316.12.2.2 Combustible Gas Detector. Combustible gas detectors shall be listed and shall be 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]

1316.12.3 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]

1317.0 Required Gas Supply.

1317.1 General. The following regulations shall comply with this section and Section 1318.0, 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, supplied at 6 to 8 inches water column (1.5 kPa to 1.9 kPa) pressure at the outlet of the meter or regulator. For undiluted liquefied petroleum gas, gas piping shall be permitted to be sized at 11 inches water column (2.7 kPa) pressure at the outlet of the meter or regulator and 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 pipe sizing tables in this chapter.

1317.2 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.

1317.3 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.

1317.4 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 ⅜ of an inch (20 mm).

1318.0 Required Gas Piping Size.

1318.1 Pipe Sizing Methods. Where the pipe size is to be determined using a method in Section 1318.1.1 through Section 1318.1.3, the diameter of each pipe segment shall be obtained from the pipe sizing tables in Section 1318.2 or from the sizing equations in Section 1318.3. [NFPA 54:6.1]

1318.1.1 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]

1318.1.2 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]

1318.1.3 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]
1318.2 Tables for Sizing Gas Piping Systems. Table 1318.2(1) through Table 1318.2(36) shall be used to size gas piping in conjunction with one of the methods described in Section 1318.1.1 through Section 1318.1.3. [NFPA 54:6.2]

1318.3 Sizing Equations. The inside diameter of smooth wall pipe or tubing shall be determined by Equation 1318.3(1), Equation 1318.3(2), Table 1318.3, and using the equivalent pipe length determined by Section 1318.1.1 through Section 1318.1.3. [NFPA 54:6.4]

\[
D = \frac{Q^{0.381}}{19.17 \left( \frac{\Delta H}{Cr \times L} \right)^{0.206}}
\]

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, in. water column
- \(Cr\) = in accordance with Table 1318.3

\[
D = \frac{Q^{0.381}}{18.93 \left[ \frac{(P_1^2 - P_2^2) \cdot Y}{Cr \times L} \right]^{0.206}}
\]

Where:
- \(D\) = inside diameter of pipe, inches
- \(Q\) = input rate of 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 1318.3
- \(Y\) = in accordance with Table 1318.3

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, \(^\circ\)C = \(^\circ\)F - 32)/1.8, 1 inch mercury column = 3.39 kPa, 1 inch water column = 0.249 kPa

1318.4 Sizing of Piping Sections. To determine the size of each section of pipe in a system within the range of Table 1318.2(1) through Table 1318.2(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 the gas demand for that outlet. Where the exact figure of demand is not shown, choose the next larger figure in the row.
4. At the top of the column in the table will be found the correct size of pipe.
5. Using this same row, proceed in a similar manner for each section of pipe serving this outlet. For each section of pipe, determine the total gas demand supplied by that section. Where gas piping sections serve both heating and cooling appliances and the installation prevents both units from operating simultaneously, the larger of the two demand loads needs to be used in sizing these sections.
6. Size each section of branch piping not previously sized by measuring the distance from the gas meter location to the 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.

1318.5 Engineering Methods. For conditions other than those covered by Section 1318.1, 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.

1318.6 Variable Gas Pressure. Where the gas pressure exceeds 14 inches (3.5 kPa) or 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 1318.1.1 Example Illustrating Use of Tables 1308.4.1 and 1318.2(1)**

**Problem:** Determine the required pipe size of each section and outlet of the piping system shown in Figure 1318.1.1. 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).
2. Maximum gas demand of Outlet B – 3 cubic feet per hour (0.08 m³/h) (from Table 1308.4.1).
3. Maximum gas demand of Outlet C – 59 cubic feet per hour (1.67 m³/h) (from Table 1308.4.1).
4. 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 1318.2(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 ¾ 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 1318.2(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.

5. Using the column marked 60 feet (18,288 mm) in Table 1318.2(1):
   - Outlet D, supplying 136 cubic feet per hour (3.85 m³/h), requires ¾ of an inch (20 mm) pipe.
### TABLE 1318.2(1)

**SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2(b)]

<table>
<thead>
<tr>
<th>GAS:</th>
<th>NATURAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INLET PRESSURE:</strong></td>
<td>LESS THAN 2 psi</td>
</tr>
<tr>
<td><strong>PRESSURE DROP:</strong></td>
<td>0.5 in. w.c.</td>
</tr>
<tr>
<td><strong>SPECIFIC GRAVITY:</strong></td>
<td>0.60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th><strong>CAPACITY IN CUBIC FEET OF GAS PER HOUR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LENGTH (feet)</strong></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>10</td>
<td>172</td>
</tr>
<tr>
<td>20</td>
<td>118</td>
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<td>40</td>
<td>81</td>
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<tr>
<td>50</td>
<td>72</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).

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 1318.2(2)
**SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2(c)]**

<table>
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<tr>
<th>NOMINAL:</th>
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<th>⅜</th>
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<th>1¼</th>
<th>1½</th>
<th>2</th>
<th>2½</th>
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<th>4</th>
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<tbody>
<tr>
<td>ACTUAL ID:</td>
<td>0.622</td>
<td>0.824</td>
<td>1.049</td>
<td>1.380</td>
<td>1.610</td>
<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
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<table>
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<tr>
<th>LENGTH (feet)</th>
<th>10</th>
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<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
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<tbody>
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<td>CAPACITY IN CUBIC FEET OF GAS PER HOUR</td>
<td>454</td>
<td>652</td>
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<td>1244</td>
<td>1900</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

* Table entries are rounded to 3 significant digits.
## TABLE 1318.2(3)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2(d)]*

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<tbody>
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<td>ACTUAL ID:</td>
<td>0.622</td>
<td>0.824</td>
<td>1.049</td>
<td>1.380</td>
<td>1.610</td>
<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
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### INTENDED USE: INITIAL SUPPLY PRESSURE OF 11.0 IN. W.C. OR GREATER

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<td>%</td>
<td>1</td>
<td>%</td>
<td>1</td>
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</table>

### GAS: NATURAL

**INLET PRESSURE:** LESS THAN 2 psi

**PRESSURE DROP:** 6.0 in. w.c.

**SPECIFIC GRAVITY:** 0.60

* 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.

---

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 1318.2(4)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2(e)]*

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<thead>
<tr>
<th>NOMINAL:</th>
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<th>⅜</th>
<th>⅝</th>
<th>⅞</th>
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<th>1¼</th>
<th>1½</th>
<th>2</th>
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<td>1.610</td>
<td>2.067</td>
<td>2.469</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.

---

**UNIFORM MECHANICAL CODE**
### TABLE 1318.2(5)
SCHEDULE 40 METALLIC PIPE (NFPA 54: TABLE 6.2(0))*

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<th>1.610</th>
<th>2.067</th>
<th>2.469</th>
<th>3.068</th>
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<tr>
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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
* Table entries are rounded to 3 significant digits.
### TABLE 1318.2(6)

**SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.2(g)]**

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<td>3.068</td>
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**GAS:**

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<td>SPECIFIC GRAVITY: 0.60</td>
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* 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

* Table entries are rounded to 3 significant digits.
# FUEL GAS PIPING

## TABLE 1318.2(7)

**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2(h)]

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<tr>
<td>SPECIFIC GRAVITY:</td>
<td>0.60</td>
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</tbody>
</table>

| TUBE SIZE (inch) | NOMINAL: | K & L: | ACR: | ¼ | ⅜ | ⅝ | ⅞ | 1 | 1¼ | 1½ | 2 |
|------------------|----------|-------|------|----|----|----|----|---|----|----|---|---|
| OUTSIDE: | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.125 | 1.375 | 1.625 | 2.125 |
| INSIDE: | 0.305 | 0.402 | 0.527 | 0.652 | 0.745 | 0.995 | 1.245 | 1.481 | 1.959 |

<table>
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<th>LENGTH (feet)</th>
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<tr>
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<tr>
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<td>11</td>
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<tr>
<td>40</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. 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 1318.2(8)

**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2(l)]**¹,²

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<th>¾</th>
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<td>½</td>
<td>¾</td>
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<td>0.995</td>
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<td>LENGTH (feet)</td>
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</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 1318.2(9)

**Semi-Rigid Copper Tubing (NFPA 54: Table 6.2(j))**

| NOMINAL: | TUBE SIZE (inch) | \( \frac{3}{4} \) | \( \frac{1}{2} \) | \( \frac{5}{32} \) | \( \frac{7}{32} \) | \( \frac{9}{32} \) | \( \frac{11}{32} \) | \( \frac{13}{32} \) | \( \frac{15}{32} \) | \( \frac{17}{32} \) | \( \frac{19}{32} \) | \( \frac{21}{32} \) | \( \frac{23}{32} \) | \( \frac{25}{32} \) |
|----------|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| K & L:   | 1.0 in. w.c.     |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |
| ACR:     |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |                 |
| OUTSIDE: | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.125 | 1.375 | 1.625 | 2.000 |
| INSIDE:  | 0.305 | 0.402 | 0.527 | 0.652 | 0.745 | 0.995 | 1.245 | 1.481 | 1.959 |
| LENGTH (feet) | CAPACITY IN CUBIC FEET OF GAS PER HOUR |
| 10       | 39               | 80               | 162             | 283             | 402             | 859             | 1550            | 2440            | 5080            |
| 20       | 27               | 55               | 111             | 195             | 276             | 590             | 1060            | 1680            | 3490            |
| 30       | 21               | 44               | 89              | 156             | 222             | 474             | 853             | 1350            | 2800            |
| 40       | 18               | 38               | 77              | 134             | 190             | 406             | 730             | 1150            | 2400            |
| 50       | 16               | 33               | 68              | 119             | 168             | 359             | 647             | 1020            | 2130            |
| 60       | 15               | 30               | 61              | 107             | 152             | 326             | 586             | 925             | 1930            |
| 70       | 13               | 28               | 57              | 99              | 140             | 300             | 539             | 851             | 1770            |
| 80       | 12               | 26               | 53              | 92              | 131             | 279             | 502             | 791             | 1650            |
| 90       | 12               | 24               | 49              | 86              | 122             | 262             | 471             | 742             | 1550            |
| 100      | 11               | 23               | 47              | 82              | 116             | 247             | 445             | 701             | 1460            |
| 125      | NA               | 20               | 41              | 72              | 103             | 219             | 394             | 622             | 1290            |
| 150      | NA               | 18               | 37              | 65              | 93              | 198             | 357             | 563             | 1170            |
| 175      | NA               | 17               | 34              | 60              | 85              | 183             | 329             | 518             | 1080            |
| 200      | NA               | 16               | 32              | 56              | 79              | 170             | 306             | 482             | 1000            |
| 250      | NA               | 14               | 28              | 50              | 70              | 151             | 271             | 427             | 890             |
| 300      | NA               | 13               | 26              | 45              | 64              | 136             | 245             | 387             | 806             |
| 350      | NA               | 12               | 24              | 41              | 59              | 125             | 226             | 356             | 742             |
| 400      | NA               | 11               | 22              | 39              | 55              | 117             | 210             | 331             | 690             |
| 450      | NA               | 10               | 21              | 36              | 51              | 110             | 197             | 311             | 647             |
| 500      | NA               | NA               | 20              | 34              | 48              | 103             | 186             | 294             | 612             |
| 550      | NA               | NA               | 19              | 32              | 46              | 98              | 177             | 279             | 581             |
| 600      | NA               | NA               | 18              | 31              | 44              | 94              | 169             | 266             | 554             |
| 650      | NA               | NA               | 17              | 30              | 42              | 90              | 162             | 255             | 531             |
| 700      | NA               | NA               | 16              | 28              | 40              | 86              | 155             | 245             | 510             |
| 750      | NA               | NA               | 16              | 27              | 39              | 83              | 150             | 236             | 491             |
| 800      | NA               | NA               | 15              | 26              | 38              | 80              | 144             | 228             | 474             |
| 850      | NA               | NA               | 15              | 26              | 36              | 78              | 140             | 220             | 459             |
| 900      | NA               | NA               | 14              | 25              | 35              | 75              | 135             | 214             | 445             |
| 950      | NA               | NA               | 14              | 24              | 34              | 73              | 132             | 207             | 432             |
| 1000     | NA               | NA               | 13              | 23              | 33              | 71              | 128             | 202             | 420             |
| 1100     | NA               | NA               | 13              | 22              | 32              | 68              | 122             | 192             | 399             |
| 1200     | NA               | NA               | 12              | 21              | 30              | 64              | 116             | 183             | 381             |
| 1300     | NA               | NA               | 12              | 20              | 29              | 62              | 111             | 175             | 365             |
| 1400     | NA               | NA               | 11              | 20              | 28              | 59              | 107             | 168             | 350             |
| 1500     | NA               | NA               | 11              | 19              | 27              | 57              | 103             | 162             | 338             |
| 1600     | NA               | NA               | 10              | 18              | 26              | 55              | 99              | 156             | 326             |
| 1700     | NA               | NA               | 10              | 18              | 25              | 53              | 96              | 151             | 315             |
| 1800     | NA               | NA               | 10              | 17              | 24              | 52              | 93              | 147             | 306             |
| 1900     | NA               | NA               | 10              | 17              | 24              | 50              | 90              | 143             | 297             |
| 2000     | NA               | NA               | 10              | 16              | 23              | 49              | 88              | 139             | 289             |

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 1318.2(10)
#### SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2(k)]

<table>
<thead>
<tr>
<th>NOMINAL LENGTH (feet)</th>
<th>K &amp; L</th>
<th>ACR</th>
<th>1⁄8</th>
<th>3⁄32</th>
<th>1⁄32</th>
<th>1⁄16</th>
<th>1⁄8</th>
<th>1⁄4</th>
<th>3⁄16</th>
<th>1⁄2</th>
<th>3⁄8</th>
<th>1⁄2</th>
<th>3⁄4</th>
<th>1</th>
<th>11⁄2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td></td>
<td>900</td>
<td>700</td>
<td>650</td>
<td>600</td>
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<td>100</td>
</tr>
<tr>
<td></td>
<td>20</td>
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<td>125</td>
<td>110</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
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<td>10</td>
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<td>120</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>OUTSIDE</th>
<th>INSIDE</th>
<th>CAPACITY IN CUBIC FEET OF GAS PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.750</td>
<td>0.305</td>
<td>140</td>
</tr>
<tr>
<td>0.500</td>
<td>0.402</td>
<td>100</td>
</tr>
<tr>
<td>0.250</td>
<td>0.527</td>
<td>65</td>
</tr>
<tr>
<td>0.125</td>
<td>0.625</td>
<td>40</td>
</tr>
<tr>
<td>0.062</td>
<td>0.652</td>
<td>25</td>
</tr>
<tr>
<td>0.031</td>
<td>0.745</td>
<td>15</td>
</tr>
<tr>
<td>0.015</td>
<td>0.995</td>
<td>10</td>
</tr>
<tr>
<td>0.0075</td>
<td>1.245</td>
<td>10</td>
</tr>
<tr>
<td>0.00375</td>
<td>1.481</td>
<td>5</td>
</tr>
<tr>
<td>0.00188</td>
<td>1.959</td>
<td>2</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 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 1318.2(11)

**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2(1)][2]**

<table>
<thead>
<tr>
<th>TUBE SIZE (inch)</th>
<th>K &amp; L:</th>
<th>ACR:</th>
<th>¼</th>
<th>½</th>
<th>³⁄₄</th>
<th>1</th>
<th>1¼</th>
<th>1½</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSIDE:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</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>
</tr>
<tr>
<td><strong>OUTSIDE:</strong></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>
</tr>
<tr>
<td><strong>LENGTH (feet)</strong></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>245</td>
<td>506</td>
<td>1030</td>
<td>1800</td>
<td>2550</td>
<td>5450</td>
<td>9820</td>
<td>15 500</td>
<td>32 200</td>
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<tr>
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<td>708</td>
<td>1240</td>
<td>1760</td>
<td>3750</td>
<td>6750</td>
<td>10 600</td>
<td>22 200</td>
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<tr>
<td>30</td>
<td>444</td>
<td>135</td>
<td>568</td>
<td>993</td>
<td>1410</td>
<td>3010</td>
<td>5420</td>
<td>8550</td>
<td>17 800</td>
</tr>
<tr>
<td>40</td>
<td>488</td>
<td>116</td>
<td>486</td>
<td>850</td>
<td>1210</td>
<td>2580</td>
<td>4640</td>
<td>7310</td>
<td>15 200</td>
</tr>
<tr>
<td>50</td>
<td>532</td>
<td>103</td>
<td>431</td>
<td>754</td>
<td>1070</td>
<td>2280</td>
<td>4110</td>
<td>6480</td>
<td>13 500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CAPACITY IN CUBIC FEET OF GAS PER HOUR</strong></th>
<th><strong>GAS:</strong> NATURAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INLET PRESSURE:</strong> 2.0 psi</td>
<td><strong>PRESSURE DROP:</strong> 1.0 psi</td>
</tr>
<tr>
<td><strong>SPECIFIC GRAVITY:</strong> 0.60</td>
<td></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

**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.

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**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 1318.2(12)**

**SEMI-RIGID COPPER TUBING [NFPA 54: TABLE 6.2(m)]**

<table>
<thead>
<tr>
<th>OUTSIDE</th>
<th>INSIDE:</th>
<th>( K \ &amp; \ L: )</th>
<th>( ACR: )</th>
<th>TUBE SIZE (inch)</th>
<th>( \frac{1}{8} )</th>
<th>( \frac{3}{8} )</th>
<th>( \frac{1}{2} )</th>
<th>( \frac{5}{8} )</th>
<th>( \frac{3}{4} )</th>
<th>( \frac{7}{8} )</th>
<th>( 1 )</th>
<th>( 1\frac{1}{8} )</th>
<th>( 1\frac{1}{4} )</th>
<th>( 2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.375</td>
<td>0.305</td>
<td>( \frac{1}{16} )</td>
<td>( \frac{1}{16} )</td>
<td>0.500</td>
<td>1300</td>
<td>2000</td>
<td>1900</td>
<td>1800</td>
<td>950</td>
<td>500</td>
<td>300</td>
<td>200</td>
<td>150</td>
<td>125</td>
</tr>
<tr>
<td>0.500</td>
<td>0.402</td>
<td>( \frac{3}{16} )</td>
<td>( \frac{3}{16} )</td>
<td>0.625</td>
<td>550</td>
<td>500</td>
<td>400</td>
<td>350</td>
<td>250</td>
<td>200</td>
<td>150</td>
<td>125</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>0.625</td>
<td>0.527</td>
<td>( \frac{1}{8} )</td>
<td>( \frac{1}{8} )</td>
<td>0.750</td>
<td>900</td>
<td>700</td>
<td>550</td>
<td>500</td>
<td>350</td>
<td>250</td>
<td>200</td>
<td>150</td>
<td>125</td>
<td>100</td>
</tr>
<tr>
<td>0.750</td>
<td>0.652</td>
<td>( \frac{5}{32} )</td>
<td>( \frac{5}{32} )</td>
<td>0.875</td>
<td>1250</td>
<td>1000</td>
<td>850</td>
<td>750</td>
<td>500</td>
<td>350</td>
<td>250</td>
<td>200</td>
<td>150</td>
<td>125</td>
</tr>
<tr>
<td>0.875</td>
<td>0.745</td>
<td>( \frac{1}{4} )</td>
<td>( \frac{1}{4} )</td>
<td>1.125</td>
<td>2025</td>
<td>1600</td>
<td>1350</td>
<td>1250</td>
<td>850</td>
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<td>480</td>
<td>350</td>
<td>250</td>
<td>200</td>
</tr>
<tr>
<td>1.125</td>
<td>0.995</td>
<td>( \frac{3}{8} )</td>
<td>( \frac{3}{8} )</td>
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<td>3250</td>
<td>2500</td>
<td>2000</td>
<td>1750</td>
<td>1250</td>
<td>900</td>
<td>700</td>
<td>550</td>
<td>450</td>
<td>350</td>
</tr>
<tr>
<td>1.375</td>
<td>1.481</td>
<td>( \frac{1}{2} )</td>
<td>( \frac{1}{2} )</td>
<td>1.625</td>
<td>4800</td>
<td>4000</td>
<td>3250</td>
<td>2750</td>
<td>2000</td>
<td>1400</td>
<td>1100</td>
<td>900</td>
<td>700</td>
<td>600</td>
</tr>
<tr>
<td>1.625</td>
<td>1.959</td>
<td>( \frac{5}{8} )</td>
<td>( \frac{5}{8} )</td>
<td>2.125</td>
<td>7500</td>
<td>6800</td>
<td>5600</td>
<td>4750</td>
<td>3500</td>
<td>2600</td>
<td>2000</td>
<td>1600</td>
<td>1400</td>
<td>1200</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. 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.

For SI units: 1 inch = 25 mm, 1 foot = 308.4 mm, 1 cubic foot per hour = 0.0283 m³/h, 1 pound-force per square inch = 6.8947 kPa
<table>
<thead>
<tr>
<th>TUBE SIZE (inch)</th>
<th>1/4</th>
<th>3/8</th>
<th>1/2</th>
<th>1 1/4</th>
<th>1 1/2</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTSIDE: 0.375</td>
<td>150</td>
<td>213</td>
<td>241</td>
<td>313</td>
<td>350</td>
<td>511</td>
</tr>
<tr>
<td>0.500</td>
<td>176</td>
<td>234</td>
<td>262</td>
<td>331</td>
<td>364</td>
<td>532</td>
</tr>
<tr>
<td>0.625</td>
<td>188</td>
<td>247</td>
<td>274</td>
<td>344</td>
<td>377</td>
<td>568</td>
</tr>
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<td>282</td>
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<td>260</td>
<td>288</td>
<td>358</td>
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<td>598</td>
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<td>231</td>
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<td>234</td>
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<td>143</td>
<td>162</td>
<td>237</td>
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<td>145</td>
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<td>240</td>
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</table>

**LENGTH (feet)**

**CAPACITY IN CUBIC FEET OF GAS PER HOUR**

<table>
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<tr>
<th>NOMINAL:</th>
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<th>30</th>
<th>40</th>
<th>50</th>
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<td>547</td>
<td>556</td>
</tr>
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<tr>
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<td>546</td>
<td>554</td>
<td>562</td>
<td>570</td>
</tr>
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<td>550</td>
<td>558</td>
<td>566</td>
<td>574</td>
</tr>
<tr>
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<td>562</td>
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<td>578</td>
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**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.
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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 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: \( L = 1.3 \times n \), 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 1318.2(15)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2(p)]

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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 1318.2(16)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2(q)]¹, ²

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.

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TABLE 1318.2(17)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2(r)] \(^1,2,3,4\)

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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 1318.2(18)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.2(s)]¹, ², ³, ⁴

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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 1318.2(19)

**POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.2(l)]**

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.

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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
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<td>477</td>
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<td>70</td>
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<td>254</td>
<td>439</td>
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<td>1190</td>
<td>3300</td>
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<td>80</td>
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<td>236</td>
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<td>3070</td>
<td>5930</td>
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<tr>
<td>90</td>
<td>61</td>
<td>123</td>
<td>221</td>
<td>383</td>
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</tr>
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<td>125</td>
<td>51</td>
<td>103</td>
<td>185</td>
<td>321</td>
<td>485</td>
<td>871</td>
<td>2410</td>
<td>4660</td>
</tr>
<tr>
<td>150</td>
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<td>93</td>
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<td>291</td>
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<td>789</td>
<td>2180</td>
<td>4220</td>
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<td>250</td>
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<td>221</td>
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<td>598</td>
<td>1660</td>
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<td>32</td>
<td>64</td>
<td>115</td>
<td>200</td>
<td>302</td>
<td>542</td>
<td>1500</td>
<td>2900</td>
</tr>
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<td>59</td>
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<td>2670</td>
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<tr>
<td>400</td>
<td>27</td>
<td>55</td>
<td>99</td>
<td>171</td>
<td>258</td>
<td>464</td>
<td>1280</td>
<td>2480</td>
</tr>
<tr>
<td>450</td>
<td>26</td>
<td>51</td>
<td>93</td>
<td>160</td>
<td>242</td>
<td>435</td>
<td>1200</td>
<td>2330</td>
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<tr>
<td>500</td>
<td>24</td>
<td>48</td>
<td>88</td>
<td>152</td>
<td>229</td>
<td>411</td>
<td>1140</td>
<td>2200</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 1318.2(21)

**POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.2(v)]**

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>1/2</th>
<th>3/4</th>
<th>1</th>
<th>1 1/4</th>
<th>1 1/2</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOMINAL OD:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDR 9.3</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>

**LENGTH (feet)** | **CAPACITY IN CUBIC FEET OF GAS PER HOUR**

| LENGTH (feet) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 125 | 150 | 175 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 |
|---------------|----|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|               | 1860 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 720 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 |
|               | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 | 3720 |
|               | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 | 6710 |
|               | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 | 11600 |
|               | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 | 17600 |
|               | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 | 31600 |
|               | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 | 63200 |
|               | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 | 126000 |

**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 1318.2(22)
**POLYETHYLENE PLASTIC TUBING [NFPA 54: TABLE 6.2(w)]**

<table>
<thead>
<tr>
<th>NOMINAL OD:</th>
<th>½</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESIGNATION:</td>
<td>SDR 7</td>
<td>SDR 11</td>
</tr>
<tr>
<td>ACTUAL ID:</td>
<td>0.445</td>
<td>0.927</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>54</td>
</tr>
<tr>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>60</td>
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<td>70</td>
<td>70</td>
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<td>80</td>
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<td>90</td>
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<tr>
<td>100</td>
<td>100</td>
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<tr>
<td>125</td>
<td>125</td>
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<tr>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>225</td>
<td>225</td>
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<tr>
<td>250</td>
<td>250</td>
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<tr>
<td>275</td>
<td>275</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>500</td>
<td>500</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 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 1318.2(23)
**POLYETHYLENE PLASTIC TUBING [NFPA 54: TABLE 6.2(x)]**

<table>
<thead>
<tr>
<th>NOMINAL OD:</th>
<th>½</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESIGNATION:</td>
<td>SDR 7</td>
<td>SDR 11</td>
</tr>
<tr>
<td>ACTUAL ID:</td>
<td>0.445</td>
<td>0.927</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>72</td>
</tr>
<tr>
<td>20</td>
<td>49</td>
</tr>
<tr>
<td>30</td>
<td>39</td>
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<td>90</td>
<td>22</td>
</tr>
<tr>
<td>100</td>
<td>21</td>
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<tr>
<td>125</td>
<td>18</td>
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<tr>
<td>150</td>
<td>17</td>
</tr>
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<td>175</td>
<td>15</td>
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<td>400</td>
<td>51</td>
</tr>
<tr>
<td>450</td>
<td>47</td>
</tr>
<tr>
<td>500</td>
<td>45</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 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 1318.2(24)

**SCHEDULE 40 METALLIC PIPE (NFPA 54: TABLE 6.3(a))***

<table>
<thead>
<tr>
<th>Pipe Size (inch)</th>
<th>Gas: Undiluted Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inlet Pressure: 10.0 psi</td>
</tr>
<tr>
<td></td>
<td>Pressure Drop: 1.0 psi</td>
</tr>
<tr>
<td></td>
<td>Specific Gravity: 1.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTENDED USE: PIPE SIZING BETWEEN FIRST STAGE (HIGH PRESSURE) REGULATOR AND SECOND STAGE (LOW PRESSURE) REGULATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIPE SIZE (inch)</td>
</tr>
<tr>
<td>NOMINAL INSIDE:</td>
</tr>
<tr>
<td>½</td>
</tr>
<tr>
<td>Actural: 0.622</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH (feet)</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>40</td>
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<tr>
<td>80</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPECIFIC GRAVITY: 1.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE DROP: 1.0 psi</td>
</tr>
<tr>
<td>INLET PRESSURE: 10.0 psi</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 1318.2(25)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.3(b)]*

<table>
<thead>
<tr>
<th>PIPE SIZE (inch)</th>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8</td>
<td>0.622</td>
</tr>
<tr>
<td>1/4</td>
<td>0.824</td>
</tr>
<tr>
<td>1</td>
<td>1.049</td>
</tr>
<tr>
<td>1 1/4</td>
<td>1.380</td>
</tr>
<tr>
<td>2</td>
<td>2.067</td>
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<td>2 1/4</td>
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<tr>
<td>3</td>
<td>3.068</td>
</tr>
<tr>
<td>4</td>
<td>4.026</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>5890</td>
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<td>4050</td>
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<td>1790</td>
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<td>100</td>
<td>1690</td>
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<td>1360</td>
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<td>1900</td>
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<tr>
<td>2000</td>
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</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.
**FUEL GAS PIPING**

**TABLE 1318.2(26)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.3(c)]**

<table>
<thead>
<tr>
<th>NOMINAL:</th>
<th>%</th>
<th>%</th>
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<th>1¼</th>
<th>1½</th>
<th>2</th>
<th>2½</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIPE SIZE (inch)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTUAL ID:</td>
<td>0.622</td>
<td>0.824</td>
<td>1.049</td>
<td>1.380</td>
<td>1.610</td>
<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
<td>4.026</td>
</tr>
<tr>
<td>LENGTH (feet)</td>
<td>CAPACITY IN THOUSANDS OF BTU PER HOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2680</td>
<td>5590</td>
<td>10 500</td>
<td>21 600</td>
<td>32 400</td>
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<td>14 900</td>
<td>22 300</td>
<td>42 900</td>
<td>68 400</td>
<td>121 000</td>
<td>247 000</td>
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<td>1480</td>
<td>3090</td>
<td>5820</td>
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<td>17 900</td>
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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 1318.2(27)
SCHEDULE 40 METALLIC PIPE [NFPA 54: TABLE 6.3(d)]*

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<th>NOMINAL INSIDE:</th>
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<th>⅜</th>
<th>⅝</th>
<th>⅞</th>
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<th>1⅛</th>
<th>1⅜</th>
<th>1⅝</th>
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<td>0.5 in. w.c.</td>
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<td>SPECIFIC GRAVITY</td>
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**INTENDED USE:** PIPE SIZING BETWEEN SINGLE OR SECOND STAGE (LOW PRESSURE) REGULATOR AND APPLIANCE

<table>
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<th>PIPE SIZE (inch)</th>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
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<td>Actual ID:</td>
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<table>
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<tr>
<th>LENGTH (feet)</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>80</th>
<th>100</th>
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<td>1.380</td>
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<td>2.067</td>
<td>2.469</td>
<td>3.068</td>
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</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.
| OUTSIDE: | 0.375 | 0.500 | 0.625 | 0.750 | 0.875 | 1.125 | 1.375 | 1.625 | 2.125 |
| INSIDE: | 0.305 | 0.402 | 0.527 | 0.652 | 0.745 | 0.995 | 1.245 | 1.481 | 1.959 |
| LENGTH (feet) | CAPACITY IN THOUSANDS OF BTU PER HOUR | TUBE SIZE (inch) | | | | | | | |
| 10 | 513 | 1060 | 2150 | 3760 | 5330 | 11400 | 20500 | 32300 | 67400 |
| 20 | 352 | 727 | 1480 | 2580 | 3670 | 7830 | 14100 | 22200 | 46300 |
| 30 | 283 | 584 | 1190 | 2080 | 2940 | 6290 | 11300 | 17900 | 37200 |
| 40 | 242 | 500 | 1020 | 1780 | 2520 | 5380 | 9690 | 15300 | 31800 |
| 50 | 215 | 443 | 901 | 1570 | 2230 | 4770 | 8590 | 13500 | 28200 |
| 60 | 194 | 401 | 816 | 1430 | 2020 | 4320 | 7750 | 12300 | 25600 |
| 70 | 179 | 369 | 751 | 1310 | 1860 | 3980 | 7160 | 11300 | 23500 |
| 80 | 166 | 343 | 699 | 1220 | 1730 | 3700 | 6660 | 10500 | 21900 |
| 90 | 156 | 322 | 655 | 1150 | 1630 | 3470 | 6250 | 9880 | 20500 |
| 100 | 147 | 304 | 619 | 1080 | 1540 | 3280 | 5900 | 9310 | 19400 |
| 125 | 131 | 270 | 549 | 959 | 1360 | 2910 | 5230 | 8250 | 17200 |
| 150 | 118 | 244 | 497 | 869 | 1230 | 2630 | 4740 | 7470 | 15600 |
| 175 | 109 | 225 | 457 | 799 | 1130 | 2420 | 4360 | 6880 | 14300 |
| 200 | 101 | 209 | 426 | 744 | 1060 | 2250 | 4060 | 6400 | 13300 |
| 250 | 90 | 185 | 377 | 659 | 935 | 2000 | 3600 | 5670 | 11800 |
| 300 | 81 | 168 | 342 | 597 | 847 | 1810 | 3260 | 5140 | 10700 |
| 350 | 75 | 155 | 314 | 549 | 779 | 1660 | 3000 | 4730 | 9840 |
| 400 | 70 | 144 | 292 | 511 | 725 | 1550 | 2790 | 4400 | 9160 |
| 450 | 65 | 135 | 274 | 480 | 680 | 1450 | 2620 | 4130 | 8590 |
| 500 | 62 | 127 | 259 | 453 | 643 | 1370 | 2470 | 3900 | 8120 |
| 550 | 59 | 121 | 246 | 430 | 610 | 1300 | 2350 | 3700 | 7710 |
| 600 | 56 | 115 | 235 | 410 | 582 | 1240 | 2240 | 3530 | 7350 |
| 650 | 54 | 111 | 225 | 393 | 558 | 1190 | 2140 | 3380 | 7040 |
| 700 | 51 | 106 | 216 | 378 | 536 | 1140 | 2060 | 3250 | 6770 |
| 750 | 50 | 102 | 208 | 364 | 516 | 1100 | 1980 | 3130 | 6520 |
| 800 | 48 | 99 | 201 | 351 | 498 | 1060 | 1920 | 3020 | 6290 |
| 850 | 46 | 96 | 195 | 340 | 482 | 1030 | 1850 | 2920 | 6090 |
| 900 | 45 | 93 | 189 | 330 | 468 | 1000 | 1800 | 2840 | 5910 |
| 950 | 44 | 90 | 183 | 320 | 454 | 970 | 1750 | 2750 | 5730 |
| 1000 | 42 | 88 | 178 | 311 | 442 | 944 | 1700 | 2680 | 5580 |
| 1100 | 40 | 83 | 169 | 296 | 420 | 896 | 1610 | 2540 | 5300 |
| 1200 | 38 | 79 | 161 | 282 | 400 | 855 | 1540 | 2430 | 5050 |
| 1300 | 37 | 76 | 155 | 270 | 383 | 819 | 1470 | 2320 | 4840 |
| 1400 | 35 | 73 | 148 | 260 | 368 | 787 | 1420 | 2230 | 4650 |
| 1500 | 34 | 70 | 143 | 250 | 355 | 758 | 1360 | 2150 | 4480 |
| 1600 | 33 | 68 | 138 | 241 | 343 | 732 | 1320 | 2080 | 4330 |
| 1700 | 32 | 66 | 134 | 234 | 331 | 708 | 1270 | 2010 | 4190 |
| 1800 | 31 | 64 | 130 | 227 | 321 | 687 | 1240 | 1950 | 4060 |
| 1900 | 30 | 62 | 126 | 220 | 312 | 667 | 1200 | 1890 | 3940 |
| 2000 | 29 | 60 | 122 | 214 | 304 | 648 | 1170 | 1840 | 3830 |

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 1318.2(29)

#### Semi-rigid Copper Tubing [NFPA 54: Table 6.3(f)]

**Gas:** Undiluted Propane

- **Inlet Pressure:** 11.0 in. w.c.
- **Pressure Drop:** 0.5 in. w.c.
- **Specific Gravity:** 1.50

#### Intended Use:Tube Sizing Between Single or Second Stage (Low Pressure) Regulator and Appliance

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</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).
**FUEL GAS PIPING**

**TABLE 1318.2(30)**

**SEMI-RIGID COPPER TUBING (NFPA 54: TABLE 6.3(g))**

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<th>½</th>
<th>¾</th>
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<th>1¼</th>
<th>1½</th>
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<td>½</td>
<td>¾</td>
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<td>1¼</td>
<td>1½</td>
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**INTENDED USE: TUBE SIZING BETWEEN 2 PSIG SERVICE AND LINE PRESSURE REGULATOR**

**CAPACITY IN THOUSANDS OF BTU PER HOUR**

<table>
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<tr>
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<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
<th>20</th>
<th>21</th>
<th>22</th>
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</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 1318.2(31)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.3(h)]¹, ²

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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: \( L = 1.3 \times n \), 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.

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 1318.2(32)
**CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.3(i)]**

**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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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 1318.2(33)
CORRUGATED STAINLESS STEEL TUBING (CSST) [NFPA 54: TABLE 6.3(j)]

GAS: UNDILUTED PROPANE

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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.
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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 1318.2(34)

**POLYETHYLENE PLASTIC PIPE [NFPA 54: TABLE 6.3(k)]**

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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.
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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 1318.2(36)
POLYETHYLENE PLASTIC TUBING [NFPA 54: TABLE 6.3(m)]

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<thead>
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<th>GAS: UNDILUTED PROPANE</th>
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<td>PRESSURE DROP: 0.5 in. w.c.</td>
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<td>SPECIFIC GRAVITY: 1.50</td>
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INTENDED USE: PE TUBE SIZING BETWEEN INTEGRAL SECOND-STAGE REGULATOR AT TANK OR SECOND-STAGE (LOW PRESSURE) REGULATOR AND BUILDING

<table>
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<tr>
<th>PLASTIC TUBING SIZE (CTS) (Inch)</th>
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<tr>
<td>NOMINAL OD: ¼ 1</td>
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<table>
<thead>
<tr>
<th>LENGTH (feet)</th>
<th>CAPACITY IN THOUSANDS OF BTU PER HOUR</th>
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<tr>
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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

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 1701.1 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-resis-
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.
CHAPTER 15
SOLAR SYSTEMS

1501.0 General.
1501.1 Applicability. See Section 1203.0 and the Uniform Solar Energy and Hydronics Code, published by the International Association of Plumbing and Mechanical Officials. The Uniform Solar Energy and Hydronics Code provides requirements that shall be permitted to be adopted as part of the code by the Authority Having Jurisdiction.
CHAPTER 16
STATIONARY POWER PLANTS

1601.0 Stationary Fuel Cell Power Plants.
1601.1 General. Stationary fuel cell power plants shall be tested in accordance with CSA FC-1 Fuel cell power plants with a power output of less than 170 607 British thermal unit per hour (Btu/h) (49.9 kW) shall be listed and installed in accordance with the manufacturer’s installation instructions. Fuel cell power plants with a power output exceeding 170 607 Btu/h (49.9 kW) shall be installed in accordance with NFPA 853. [NFPA 54:10.31]

1602.0 Stationary Gas Engines and Generators.
1602.1 General. The installation of gas engines shall be in accordance with NFPA 37. [NFPA 54:10.24]
1602.2 Connection to the Gas Supply Piping. Stationary gas engines shall not be rigidly connected to the gas supply piping. [NFPA 54:10.24.1]
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

Note: Referenced sections in Table 1701.1 will be updated before publishing.

1701.0 General.

1701.1 Standards. The standards listed in Table 1701.1 are intended for use in the design, testing, and installation of materials, devices, appliances, and equipment regulated by this code. These standards are mandatory where required by sections in this code.

Organization abbreviations referred to in Table 1701.1 are defined in a list found at the end of the table.
### Table 1701.0

**Referenced Standards**

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<th>Standard Number</th>
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<td><strong>ACCA Manual B-2009</strong></td>
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<td><strong>ACCA Manual D-2009</strong></td>
<td>Residential Duct Systems</td>
<td>Ducts, Balancing</td>
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<td><strong>ACCA Manual J-2011</strong></td>
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<td>Maintenance of Residential HVAC Systems</td>
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<td>Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets</td>
<td>Commercial Refrigerated Display Merchandisers and Storage Cabinets</td>
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<td>Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment</td>
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* ANSI designated as an American National Standard.

**Italic/Bold referenced standards indicate where such standards are located in the narrative of the code.**

**Notes:**

1 Although these standards are referenced in Chapter 17, some of the materials and equipment in the standards are not acceptable for use under the provisions of this code.

2 See Section 1211.42 for restrictions.
ABBREVIATIONS IN TABLE 1701.1

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<td>AABC</td>
<td>Associated Air Balance Council, 1518 K St. NW, Suite 503 Washington, DC 20005.</td>
</tr>
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<td>ACCA</td>
<td>Air Conditioning Contractors of America Association, Inc., 2800 Shirlington Road, Suite 300, Arlington, VA 22206.</td>
</tr>
<tr>
<td>AMCA</td>
<td>Air Movement and Control Association, 30 West University Dr. Arlington Heights, IL 60004-1806.</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute, Inc., 25 W. 43rd Street, 4th Floor, New York, NY 10036.</td>
</tr>
<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 Engineers, Three Park Avenue, New York, NY 10016-5990.</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, 550 N.W. LeJeune Road, Miami, FL, 33126.</td>
</tr>
<tr>
<td>AWWA</td>
<td>American Water Works Association, 6666 W. Quincy Ave., Denver, CO 80235.</td>
</tr>
<tr>
<td>CGSB</td>
<td>Canadian General Standards Board, 11 Laurier Street Phase III, Place du Portage, 6B1, Gatineau, Quebec, Canada K1A 0S5.</td>
</tr>
<tr>
<td>CGA</td>
<td>Compressed Gas Association, 1401 George Carter Way, Suite 103, Chantilly, VA 20151.</td>
</tr>
<tr>
<td>IAPMO</td>
<td>International Association of Plumbing and Mechanical Officials, 5001 E. Philadelphia Street, Ontario, CA 91761.</td>
</tr>
<tr>
<td>IAS</td>
<td>International Approval Services, A Division of CSA, 8501 East Pleasant Valley Road Cleveland, OH 44131.</td>
</tr>
<tr>
<td>I-B-R</td>
<td>Institute of Boiler and Radiator Manufacturers, 35 Russo Place, Berkeley Heights, NJ 07922.</td>
</tr>
<tr>
<td>ILAR</td>
<td>International Institute of Ammonia Refrigeration, 1110 North Glebe Road, Arlington, VA 22201.</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 Fitting Industry, 127 Park Street NE, Vienna, VA 22180.</td>
</tr>
<tr>
<td>NEBB</td>
<td>National Environmental Balancing Bureau (NEBB) 8575 Greenmount Circle, Gaithersburg, MD 20877.</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02169-9101.</td>
</tr>
<tr>
<td>PPI</td>
<td>Plastic Pipe Institute, 105 Recker Court, Suite 825, Irving, TX 75062.</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.</td>
</tr>
<tr>
<td>SMACNA</td>
<td>Sheet Metal and Air Conditioning Contractors National Association, 4201 Lafayette Center Drive, Chantilly, VA 20151-1209.</td>
</tr>
<tr>
<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 PLAN 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)

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**HVAC LOAD CALCULATION (UMC 1106.1)**

<table>
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<tr>
<th>Design Conditions</th>
<th>Building Construction Information</th>
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</thead>
<tbody>
<tr>
<td><strong>Winter Design Conditions</strong></td>
<td><strong>Building Orientation (Front door faces)</strong></td>
</tr>
<tr>
<td>Outdoor temperature <strong>°F</strong></td>
<td><strong>North, East, West, South, Northeast, Northwest, Southeast, Southwest</strong></td>
</tr>
<tr>
<td>Indoor temperature <strong>°F</strong></td>
<td><strong>Number of bedrooms</strong></td>
</tr>
<tr>
<td>Total heat loss <strong>Btu</strong></td>
<td>**Conditioned floor area <strong>Sq Ft</strong></td>
</tr>
<tr>
<td><strong>Summer Design Conditions</strong></td>
<td><strong>Windows</strong></td>
</tr>
<tr>
<td>Outdoor temperature <strong>°F</strong></td>
<td>**Eave overhang depth <strong>Ft</strong></td>
</tr>
<tr>
<td>Indoor temperature <strong>°F</strong></td>
<td><strong>Internal shade</strong></td>
</tr>
<tr>
<td>Grains difference <strong>Δ Gr @ % Rh</strong></td>
<td><strong>Blinds, drapes, etc.</strong></td>
</tr>
<tr>
<td>Sensible heat gain <strong>Btu</strong></td>
<td><strong>Number of skylights</strong></td>
</tr>
<tr>
<td>Latent heat gain <strong>Btu</strong></td>
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<tr>
<td>Total heat gain <strong>Btu</strong></td>
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**HVAC EQUIPMENT SELECTION**

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<th>Heating Equipment Data</th>
<th>Cooling Equipment Data</th>
<th>Blower Data</th>
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<tr>
<td>Equipment type</td>
<td>Equipment type</td>
<td>Heating CFM <strong>CFM</strong></td>
</tr>
<tr>
<td>Furnace, Heat pump, boiler, etc.</td>
<td>Air conditioner, heat pump, etc.</td>
<td>Cooling CFM <strong>CFM</strong></td>
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<tr>
<td>Model</td>
<td>Model</td>
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<tr>
<td>Heating output capacity <strong>Btu</strong></td>
<td>Sensible cooling capacity <strong>Btu</strong></td>
<td>Static pressure <strong>IWC</strong></td>
</tr>
<tr>
<td>Heat pump - capacity at winter design outdoor conditions</td>
<td>Latent cooling capacity <strong>Btu</strong></td>
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<td>Auxiliary heat output capacity <strong>Btu</strong></td>
<td>Total cooling capacity <strong>Btu</strong></td>
<td>Fan's rated external static pressure for design airflow</td>
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**HVAC DUCT DISTRIBUTION SYSTEM DESIGN (UMC 601.2)**

<table>
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<th>Longest supply duct: <strong>Ft</strong></th>
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</thead>
<tbody>
<tr>
<td>External Static Pressure (ESP) <strong>IWC</strong></td>
<td>Longest return duct: <strong>Ft</strong></td>
</tr>
<tr>
<td>Component Pressure Losses (CPL) <strong>IWC</strong></td>
<td>Total Effective Length (TEL) <strong>Ft</strong></td>
</tr>
<tr>
<td>Available Static Pressure (ASP) <strong>IWC</strong></td>
<td>Friction Rate: <strong>IWC</strong></td>
</tr>
</tbody>
</table>

\[
\text{Friction Rate} = \frac{\text{ASP} \times \text{CFM} \times 1000}{\text{TEL}}
\]

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 MIIAE Form based on Abridged Edition Checklist.*

---

UNIFORM MECHANICAL CODE 2009
B 1.0 101.0 Adjusting the Burner Input.

B 1.1 101.1 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 shall 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]

B 1.2 101.2 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 2.0 102.0 Primary Air Adjustment.

B 2.1 102.1 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 54:11.2]

B 3.0 103.0 Safety Shutoff Devices.

B 3.1 103.1 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 4.0 104.0 Automatic Ignition.

B 4.1 104.1 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 instructions. [NFPA 54:11.4]

B 5.0 105.0 Protective Devices.

B 5.1 105.1 General. Where required by the manufacturer’s instructions, 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. Adjustments made shall be in accordance with the manufacturer’s instructions. [NFPA 54:11.5]

B 6.0 106.0 Checking the Draft.

B 6.1 106.1 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 7.0 107.0 Operating Instructions.

B 7.1 107.1 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]
C 101.0 General.
C 1.1 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 2.0 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 D 396, 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.
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 3.9 103.0 Standards and Accepted Practices.

C 3.1 103.1 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 4.0 104.0 Approval of Equipment.

C 4.1 104.1 General. Oil- or liquid-fuel-burning equipment shall be approved.

C 5.0 105.0 Placing Equipment in Operation.

C 5.1 105.1 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 6.0 Pilot Operation.

C 6.1 106.1 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 7.0 107.0 Burner Operation.

C 7.1 107.1 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 8.0 108.0 Method of Test.

C 8.1 108.1 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 9.109.1(2), Section C 9.109.1(3), and Section C 9.109.1(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 8.108.1(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 8.108.1(10)(a).
APPENDIX C

(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 9.0 109.0 Special Requirements Based on Btu/h Input.

C 9.1 109.1 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.

   Direct-spark ignition shall be allowed where approved by the Authority Having Jurisdiction and where used on number 2 or lighter oil.
   (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 3,663.3 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 (3,663.4 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) 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.
(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 1.0 101.0 Fuel Gas Piping Systems.
D 1.1 101.1 General. 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 comply with the criteria of the Authority Having Jurisdiction. [NFPA 501A:4.1.1]

D 1.2 101.2 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 in a work-like manner. For the installation of liquefied petroleum gas (LPG) storage systems, the applicable provisions of NFPA 58 shall be followed. [NFPA 501A:4.1.2]

D 1.3 101.3 Location of Gas Supply Connection. The gas supply to the M/H shall be located within 4 feet (1219 mm) of the M/H stand.

Exception: Gas supply connections for manufactured homes located on all-weather wood, concrete, 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 1.4 101.4 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 2.0 102.0 Single and Multiple Manufactured Home Site Fuel Supply Systems.
D 2.1 102.1 Underground Installation. Underground gas piping system installations shall comply with the building code and Section D 102.1.1 and Section D 102.1.2. [NFPA 501A:4.2.1]

D 2.1.1 102.1.1 Open-Ended Gastight Conduit. Underground gas piping shall not be installed beneath that portion of a M/H 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 2.1.2 102.1.2 Requirements. The open-ended gastight conduit shall comply with 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 3/4 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, accessory building, or structure, and the outer ends shall not be sealed.
4. Where the conduit terminates within a M/H, accessory building, or structure, it shall be readily 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]

D 2.0 103.0 Manufactured Home Site Gas Shutoff Valve.
D 2.1 103.1 General. Each M/H site shall have a listed gas shutoff valve installed upstream of the M/H 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 finished grade. A gas shutoff valve shall not be located under a M/H. The outlet shall be equipped with a cap or plug to prevent discharge of gas where the M/H site outlet is not connected to a M/H.

Exception: Gas shutoff valves 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 4.0 104.0 Gas Meters.
D 4.1 104.1 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 4.2 104.2 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 is 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]

D 4.3 104.3 Meter Shutoff Valve or Cock. 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. 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]

D 5.0 Multiple Manufactured Home Site Fuel Distribution and Supply Systems. [NFPA 501A:4.3.1, 4.3.11, 4.4, and 4.4.5]

D 6.0 105.0 Cathodic Protection Requirements.
D 6.1 105.1 General. Cathodic protection shall be installed for corrosion control of buried or submerged metallic gas piping in accordance with the following requirements:
D 7.0 106.0 Manufactured Home Community LPG Supply Systems.

D 7.1 106.1 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 supply systems and the storage and handling of LPG shall be in accordance with NFPA 58 (see Section D 113.0). [NFPA 501A:4.3.2]

D 8.0 107.0 Required Gas Supply.

D 8.1 107.1 General. The minimum hourly volume of gas required at each M/H site outlet or a section of the M/H community gas piping system shall be calculated as shown in Table D 8.1 107.1. [NFPA 501A:4.3.4.1]

<table>
<thead>
<tr>
<th>NUMBER OF M/H SITES</th>
<th>BRITISH THERMAL UNITS PER HOUR PER M/H SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>125 000</td>
</tr>
<tr>
<td>2</td>
<td>117 000</td>
</tr>
<tr>
<td>3</td>
<td>104 000</td>
</tr>
<tr>
<td>4</td>
<td>96 000</td>
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<td>92 000</td>
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<td>31–40</td>
<td>58 000</td>
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<tr>
<td>41–60</td>
<td>55 000</td>
</tr>
<tr>
<td>Over 60</td>
<td>50 000</td>
</tr>
</tbody>
</table>

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

* In extreme climate areas, additional capacities shall be considered.

D 8.2 108.0 Gas Pipe Sizing and Pressure.

D 8.3 108.1 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 8.2 108.2 Pressure. Where 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 10.0 109.0 Gas Piping Materials.

D 10.1 109.1 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 A 254. Copper tubing shall comply with ASTM B 88 or ASTM B 280. Copper tubing (unless tinned) shall not be used where 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:4.3.6.1]

D 10.2 109.2 Protection Coatings for Metal Gas Piping. Buried or submerged metallic gas piping shall be protected from corrosion by approved coatings or wrapping materials. Gas pipe protective coatings shall be approved types, machine applied, and shall comply with recognized standards. Field wrapping shall provide equivalent protection and is restricted to those short sections and fittings that are stripped for threading or welding. Risers shall be coated or wrapped to a point not less than 6 inches (152 mm) aboveground. [NFPA 501A:4.3.6.2]

D 10.3 109.3 Plastic. Plastic piping shall be used underground and shall be in accordance with the requirements of ASTM D 2513 or ASTM D 2517, as well as the design pressure and design limitations of 49 CFR 192.123, and shall otherwise comply with the installation requirements thereof. [NFPA 501A:4.3.6.3]

D 11.0 110.0 Gas Piping Installations.

D 11.1 110.1 Minimum Burial Below Ground Level and Clearances. Gas piping installed below ground level shall have an earth cover of not less than 18 inches (457 mm) and shall be installed with not less than 12 inches (305 mm) of clearance from other underground utility systems. [NFPA 501A:4.3.7.1]

D 11.2 110.2 Metallic Gas Piping. 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 in accordance with the provisions of 49 CFR 192. [NFPA 501A:4.3.7.2.1, 4.3.7.2.2]
D 44.2.4 110.2.1 Cathodic Protection. Where the cathodic protection system is designed to protect the gas piping system, the gas piping system shall be electrically isolated from other underground metallic systems or installations. Where the gas piping system is cathodically protected against corrosion, a dielectric fitting shall be used in the M/H gas connection to insulate the M/H from the underground gas piping system. [NFPA 501A:4.3.7.2.3, 4.3.7.2.4]

D 44.2.2 110.2.2 Underground Metallic Systems. Where a cathodic protection system is designed to provide underground metallic systems and installations with protection against corrosion, such systems and installations shall be electrically bonded together and protected as a whole. [NFPA 501A:4.3.7.2.5]

D 44.3 110.3 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 than No. 18 AWG, with insulation approved for direct burial. Portions of a plastic gas piping system consisting of metallic pipe shall be cathodically protected against corrosion. [NFPA 501A:4.3.7.3]

D 44.4 110.4 Gas Piping System Shutoff Valve. An accessible and identifiable shutoff valve controlling the flow of gas to the entire M/H community gas piping system shall be installed in a location approved by the Authority Having Jurisdiction and near the point of connection to the service piping or to the supply connection of an LPG container. [NFPA 501A:4.3.7.4]

D 44.0 113.0 Liquefied Petroleum Gas Appliances. D 113.0 111.1 General. LPG equipment shall be installed in accordance with the applicable provisions of NFPA 58. [NFPA 501A:4.3.8]

D 44.0 112.0 Oil Supply. D 112.1 General. The following three methods of supplying oil to an individual M/H site shall be permitted:

1. Supply from an outside underground tank.
2. Supply from a centralized oil distribution system designed and installed in accordance with accepted engineering practices and in accordance with NFPA 31.
3. Supply from an outside aboveground tank. [NFPA 501A:4.3.9]

D 44.0 112.2 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 44.0 112.3 Oil Supply Connections. Oil supply connections at M/H sites, where provided from a centralized oil distribution system, shall be located and arranged to permit attachment in a work-like manner to a M/H 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 to exceed 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. Where 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. Where located aboveground, the connections shall be located within the diked area.
6. A readily accessible and identified manual shutoff valve shall be installed in each branch supply pipeline that enters a building, mobile home, travel trailer, or other structure. This valve shall be permitted to be either inside or outside of the structure. Where outside, the valve shall be protected from weather and damage. Where 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 supply, where 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. This device shall be solidly supported and protected from damage.
8. Means shall be provided to limit the oil pressure at the appliance inlet to not exceed 3 pound-force per square inch gauge (psig) (21 kPa). Where a pressure-reducing valve is used, it shall be a type approved for the service.
9. A device shall be provided that automatically shuts off the oil supply to the appliance where the oil pressure at the appliance inlet exceeds 8 psig (55 kPa).

Exceptions:

(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 pressure at the appliance inlet shall not exceed 8 psig (55 kPa).
(b) Where a means is provided to automatically shut off the oil supply where the pressure-regulating device fails to regulate the pressure as required.

10. 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 44.0 113.0 Fuel Supply Systems Installation. D 44.1 113.1 Flexible Gas Connector. Each gas supply connector shall be listed for outside M/H use, shall be not more than 6 feet (1829 mm) in length, and shall have a capacity rating adequate to supply the connected load.
Exception: Gas supply connections for manufactured homes located on all-weather wood, concrete, 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. [NFPA 501A:4.4.1]

D 44.2 113.2 Use of Approved Pipe and Fittings of Extension. Where it is necessary to extend the M/H 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 inlet and shall be supported at not more than 4 foot (1219 mm) intervals to the M/H. [NFPA 501A:4.4.2]

D 44.3 113.3 Mechanical Protection. Gas outlet risers, regulators, meters, valves, or other exposed equipment shall be protected against accidental damage. [NFPA 501A:4.4.3]

D 44.4 113.4 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 devices shall be provided to guard against closing of the vent opening. [NFPA 501A:4.4.4]

D 44.5 113.5 Fuel Gas Piping Test. The M/H fuel gas piping system shall be tested with air before it is connected to the gas supply. The M/H gas piping system shall be subjected to a pressure test with appliance shutoff valves in their closed positions. [NFPA 501A:4.4.5]

D 44.5.1 113.5.1 Procedures. The fuel gas piping test shall consist of air pressure of 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 1/8 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 gas supply connector shall be installed, and the connections shall be tested with soapy water or bubble solution. [NFPA 501A:4.4.5.1]

D 44.5.2 113.5.2 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 44.6 113.5.3 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 44.6.1 113.6 Oil Tanks. Not more than one 660 gallon (2498 L) tank or two tanks with aggregate capacity of 660 gallons (2498 L) or less shall be connected to one oil-burning appliance. Two supply tanks, where used, shall be cross-connected and provided with a single fill and single vent in accordance with NFPA 31, and shall be on a common slab and rigidly secured one to the other. 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]

D 44.6.1 113.6.1 Installation. Oil supply tanks shall be installed in accordance with the applicable provisions of NFPA 31. [NFPA 501A:4.4.6.1]

D 44.6.2 113.6.2 Capacity. A tank with a capacity not 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 of the ASME Boiler and Pressure Vessel Code. [NFPA 501A:4.4.6.2]

D 44.6.3 113.6.3 Location. Tanks, as described in Section D 113.6.2 D 113.6.6 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 44.6.4 113.6.4 Vent. Tanks with a capacity not larger than 660 gallons (2498 L) shall be equipped with an open vent not smaller than 1/8 inch (40 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 44.6.5 113.6.5 Liquid Level. Tanks shall be provided with a means of determining the liquid level. [NFPA 501A:4.4.6.5]

D 44.6.6 113.6.6 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 15.0 114.0 Manufactured Home Accessory Building Fuel Supply Systems.

D 15.1 114.1 General. Fuel gas supply systems installed in a M/H 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]

D 16.0 115.0 Community Building Fuel Supply Systems in Manufactured Home Communities.

D 16.1 115.1 Fuel Gas Piping and Equipment Installations. Fuel gas piping and equipment installed within a
permanent building in a M/H 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]

D 16.2 **115.2 Oil Supply Systems in M/H Communities.** Oil-burning equipment and installations within a M/H 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]

D 16.3 **115.3 Oil-Burning Equipment and Installation.** Oil-burning equipment and installations within a building constructed in a M/H 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 installation shall be designed and installed in accordance with NFPA 31. [NFPA 501A:4.6.3]

D 16.4 **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 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 201.3 Geothermal. Renewable energy generated by deep-earth.
E 201.4 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 201.5 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 201.6 Integrated Part-Load Value (IPLV). A single-number figure of merit based on part-load EER, COP, 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 201.7 Maintenance. The upkeep of property or equipment by the owner of the property in accordance with the requirements of this appendix.
E 201.8 Minimum Efficiency Reporting Value (MERV). Filter minimum efficiency reporting value, in accordance with ASHRAE 52.2.
E 201.9 Multi-Occupant Spaces. Indoor spaces used for presentations and training, including classrooms and conference rooms.
E 201.10 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 201.11 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 build-
ings connected to a public water system, including municip-
ally 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 collect-
ively 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 (ft³/min) (14.1584 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 of cooling where system controls are set to
maximum water use. Water use, expressed in maximum water
use per ton-hour 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 403.5 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 recy-
cled water is capable of coming in contact with employees or members of the public.

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 airgap 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 501.0 Heating, Ventilation and Air-Conditioning
Systems and Equipment - Energy Efficiency.
E 501.1 Scope. The provisions of this section shall estab-
lish the means of enhancing energy efficiency associated with
mechanical systems in a building.
APPENDIX E


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 British thermal units per hour (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 502.4.3.1 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 [0.00005 (m²)/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 (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 90.2:6.6.5]

E 502.6 Ventilation and Combustion Air. This section shall regulate only equipment using single-phase electric power, air conditioners, and heat pumps with rated cooling capacities less than 65 000 British thermal units per hour (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 90.2:6.6.1]

(Equation E 502.6)

Mechanical Ventilation = [(0.35 − Summer) × Volume] / 60

Where:

Mechanical Ventilation = required mechanical ventilation rate to supplement summer infiltration, cfm

Volume = volume of conditioned space, ft³

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]

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

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### TABLE E 502.5
MINIMUM PIPE INSULATION THICKNESS1, 5
[ASHRAE 90.2: TABLE 6.5]

<table>
<thead>
<tr>
<th>INSULATION CONDUCTIVITY</th>
<th>NOMINAL PIPE DIAMETER (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLUID DESIGN OPERATING TEMPERATURE RANGE (°F)</td>
<td>HEATING SYSTEMS (STEAM, STEAM CONDENSATE, AND HOT WATER)2, 3</td>
</tr>
<tr>
<td>mean rating temperature (°F)</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Btu/inch/(h•ft²•°F)</td>
<td>201–250</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>COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)4</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>

Notes:
1 For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows:

\[
T = r\left(1 + \frac{t}{r}K/k - 1\right)
\]

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 retards, 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 crawlspaces are considered exposed to outdoor air.

### TABLE E 502.6
VENTILATION AIR
[ASHRAE 90.2: TABLE 6.6.1]

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>MINIMUM REQUIREMENT</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical ventilation1</td>
<td>50 ft³/min outdoor air</td>
<td>Where summer design infiltration rate calculated in accordance with reference standard A or B is less than 0.35 ach².</td>
</tr>
<tr>
<td>Kitchen exhaust</td>
<td>100 ft³/min intermittent</td>
<td>All conditions</td>
</tr>
<tr>
<td>Bath exhaust</td>
<td>intermittent</td>
<td>All conditions</td>
</tr>
</tbody>
</table>

Notes:
1 Calculate in accordance with Equation E 502.6.
2 Reference standards:
(a) ACCA Manual J
(b) ASHRAE GRP-158

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For SI units: °C= (°F-32)/1.8, 1 British thermal unit inch per hour square foot degree Fahrenheit = [0.1 W/(m•K)], 1 inch = 25 mm
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 @ 70°F Ent. Water</td>
<td>ISO 13256-4 ARI 325</td>
</tr>
<tr>
<td></td>
<td>Heating Mode</td>
<td>11.5 EER @ 85°F Ent. Water</td>
<td>ISO 13256-4 ARI 325</td>
</tr>
<tr>
<td>Unitary A/C</td>
<td>Water cooled split system</td>
<td>9.3 EER @ 75°F Ent. Water</td>
<td>ARI 210/240</td>
</tr>
<tr>
<td></td>
<td>Evaporatively cooled split system</td>
<td>9.3 EER @ 75°F Ent. Water</td>
<td>ARI 210/240</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 Standard 325.

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 deadband, the range of which includes a setting of 10°F (−12°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 relative humidity within the space above 30 percent. [ASHRAE 90.2:6.10.3.1]

E 502.10.3.1 Cooling. Where additional energy-consuming equipment is provided for reducing humidity, it shall be equipped with controls 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 shutting 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 shutting 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 shutting 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, multifamily structures of not more than three stories above grade, and modular houses, shall be in accordance with this Section E 503.0.

E 503.1.1 New Buildings. Mechanical equipment and systems serving the heating, cooling, or 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, or 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.

Exception: Where HVACR to an addition is provided by existing HVACR systems and equipment, such existing systems and equipment shall not be required to be in accordance with this appendix. However, new systems or equipment installed shall be in accordance with specific requirements applicable to those systems and equipment. [ASHRAE 90.1:6.1.1.2]

E 503.1.3 Alterations to Heating, Ventilating, and Air-Conditioning, and Refrigeration in Existing Buildings. New HVACR equipment as a direct replacement of existing HVACR equipment shall be in accordance with the specific minimum efficiency requirements applicable to that equipment. [ASHRAE 90.1:6.1.1.3.1]

E 503.1.3.1 New Cooling Systems. New cooling systems installed to serve previously uncooled spaces shall be in accordance with this section as described in Section E 503.2. [ASHRAE 90.1:6.1.1.3.2]

E 503.1.3.2 Existing Cooling Systems. Alterations to existing cooling systems shall not decrease economizer capability unless the system is in accordance with Section E 503.5 through Section 503.5.4.1. [ASHRAE 90.1:6.1.1.3.3]

E 503.1.3.3 Ductwork. New and replacement ductwork shall comply with Section E 503.4.7.1 and through Section E 503.4.7.2(A). [ASHRAE 90.1:6.1.1.3.4]

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 for the following or both 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 pipes piping where there is insufficient space or access to meet 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 and Section E 503.3.4. 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 503.5. [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; provided such projects are in accordance 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 is 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. Each 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. [ASHRAE 90.1:6.3.2(a)]

2. The equipment shall comply with the variable flow requirements of Section E 503.5.1. [ASHRAE 90.1:6.3.2(b)]

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) (air conditioners), Table E 503.7.1(2) (heat pumps), or Table E 503.7.1(4) (packaged and room air conditioners and heat pumps) for the applicable equipment category. [ASHRAE 90.1:6.3.2(c)]

4. The system shall have an air economizer in accordance with Section E 503.5.4 through Section E 503.5.4.1. [ASHRAE 90.1:6.3.2(d)]

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) (heat pumps) or Table E 503.7.1(4) (packaged and room air conditioners and heat pumps), a fuel-fired furnace that meets is in accordance with the applicable efficiency requirements shown in Table E 503.7.1(5) (furnaces, duct furnaces, and unit heaters), an electric resistance heater, or a baseboard system connected to a boiler that meets is in accordance with the applicable efficiency requirements shown in Table E 503.7.1(6) (boilers). [ASHRAE 90.1:6.3.2(e)]
(6) The system shall comply with the exhaust air energy requirements in accordance with Section E 503.5.10. [ASHRAE 90.1:6.3.2(f)]

(7) The system shall be controlled by a manual changeover or dual setpoint thermostat. [ASHRAE 90.1:6.2.2(g)]

(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 outside outdoor air temperature is less than 40°F (4°C).

Exceptions: Heat Pumps that comply with the following:

(1) Have heat pumps whose minimum efficiency is regulated by NAECA and whose HSPF rating are both

(2) In accordance with the requirements shown in Table E 503.7.1(2), and

(3) Includes usage of internal electric resistance heating that are exempted from the control requirements of this part [Section E 503.3.1(8)]. [ASHRAE 90.1:6.3.2(h)]

(9) The system controls shall not permit reheat or other form of simultaneous heating and cooling for humidity control. [ASHRAE 90.1:6.3.2(i)]

(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 greater than 15 000 Btu/h (4.4 kW) and a supply fan motor power greater 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) 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) Capable of temperature setback down to 55°F (13°C) during off hours.

(e) Capable of temperature setup to 90°F (32°C) during off hours. [ASHRAE 90.1:6.3.2(m)]

(11) Except for piping within manufacturer’s units, HVAC piping shall be insulated in accordance with Table E 503.7.2(2) and Table E 503.7.2(4) in accordance with Table E 503.7.2(4) Section E 503.4.7.2. [ASHRAE 90.1:6.3.2(n)]

(12) Ductwork and plenums shall be insulated in accordance with Table E 503.7.2(1) and Table E 503.7.2(2) and shall be sealed in accordance with Table E 503.7.2(3) and Table E 503.7.2(4) and shall be sealed in accordance with Table E 503.7.2(4) and Table E 503.7.2(5). [ASHRAE 90.1:6.3.2(o)]

(13) Construction documents shall require a ducted system to be air balanced in accordance with industry-accepted procedures. [ASHRAE 90.1:6.3.2(p)]

(14) Outdoor air intake and exhaust systems shall comply with Section E 503.4.6.4 through Section E 503.4.6.5. [ASHRAE 90.1:6.3.2(q)]

(15) Where separate heating and cooling equipment serves the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling. [ASHRAE 90.1:6.3.2(r)]

(16) Systems with a design supply air capacity more than 10 000 ft³/min (4.7195 m³/s) shall have optimum start controls. [ASHRAE 90.1:6.3.2(s)]

(17) The system shall comply with the demand control ventilation requirements of Section E 503.4.6.9. [ASHRAE 90.1:6.3.2(t)]

(18) The system shall comply with the door switch requirements of Section E 503.5.14. [ASHRAE 90.1:6.3.2(u)]

E 503.3.2 Climate Zone Determination. Climate zones identified in this appendix shall be determined in accordance with ASHRAE 90.1.

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(14) shall have a minimum performance at the specified rating conditions where tested in accordance with the specified test procedures.
APPENDIX E

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 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
2. Table E 503.7.1(2) – Electrically Operated Unitary and Applied Heat Pumps
3. Table E 503.7.1(3) – Water-Chilling (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
5. Table E 503.7.1(5) – Warm-Air Furnaces, Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters
6. Table E 503.7.1(6) – Gas- and Oil-Fired Boilers
7. Table E 503.7.1(7) – Performance Requirements for Heat Rejection Equipment
8. Table E 503.7.1(8) – Heat Transfer Equipment
9. Table E 503.7.1(9) – Electrically Operated Variable-Refrigerant-Flow Air Conditioners
10. Table E 503.7.1(10) – Electrically Operated Variable-Refrigerant-Flow Air-to-Air and Applied Heat Pump
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
13. Table E 503.7.1(13) – Commercial Refrigeration

Furnaces with input ratings of not less than 225 000 Btu/h (66 kW), 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 under the scope of ASHRAE 127 shall be in accordance with Table E 503.7.1(11). Other air conditioners shall comply with 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°F (7°C) leaving chilled fluid temperature and 2.4 gallons per minute per ton (gpm/ton) (0.00015 L/s/kg) evaporator fluid flow and 85°F (29°C) entering condenser-fluid temperature with 3.0 gallons per minute per ton (gpm/ton) (0.000218 L/s/kg) condenser-fluid flow shall have maximum full-load kW/ton (FL) and NPLV part-load ratings requirements adjusted using the following equation in accordance with Equation E 503.4.1(1) through Equation E 503.4.1(3):

(Equation E 503.4.1)

Adjusted maximum full-load kW/ton rating = [full-load kW/ton from Table E 503.7.1(3) / FLadj]

Adjusted maximum NPLV rating = [IPLV from Table E 503.7.1(3) / PLVadj]

Where:

\[ FL = \text{full-load kW/ton value from Table E 503.7.1(3)} \]
\[ FLadj = \text{maximum full-load kW/ton rating, adjusted for nonstandard conditions} \]
\[ IPLV = \text{IPLV value from Table E 503.7.1(3)} \]
\[ IPLVadj = \text{maximum NPLV rating, adjusted for nonstandard conditions} \]

\[ A = 0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.0932 \]
\[ B = 0.0015 \times \text{LvgEvap} + 0.934 \]
\[ LIFT = \text{LvgCond} - \text{LvgEvap} \]
\[ \text{LvgCond} = \text{Full-load condenser leaving fluid temperature (°F)} \]
\[ \text{LvgEvap} = \text{Full-load evaporator leaving temperature (°F)} \]

The adjusted full-load FLadj and NPLVadj values shall only be applicable for centrifugal chillers in accordance with the following full-load design ranges:

1. Minimum Evaporator Leaving Temperature: 36°F (2°C)
2. Maximum Condenser Leaving Temperature: 115°F (46°C)
3. LIFT is not less than 20°F (-6°C) and not more than 80°F (27°C)

Manufacturers shall calculate the adjusted maximum kW/ton FLadj and NPLVadj before determining whether to label the chiller in accordance with Section E 503.4.4. Chillers shall be labeled in accordance with this appendix. 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 are not be covered under this appendix.
Example: Path A, 600 ton (600 000 kg) centrifugal chiller Table E 503.7.1(3) efficiencies.

Full Load $F = 0.5700 \times 560 \text{ kW/ton}$

$IPLV = 0.5390 \times 500 \text{ kW/ton}$

$LvgCond = 91.16\text{°F}$

$LvgEvap = 42\text{°F}$

$LIFT = 91.16\text{°F} - 42\text{°F} = 49.16\text{°F}$

$K_{adj} = A \times B$

$A = 0.0000014592 \times (49.16)^4 - 0.0000346496 \times (49.16)^3 + 0.00314196 \times (49.16)^2 - 0.147199 \times (49.16) + 3.9302$

$= 1.0228$

$B = 0.0015 \times 42 + 0.934 = 0.9970$

$\text{Adjusted full load:}$

$FL_{adj} = 0.5700 \times 560 / (1.0228 \times 0.9970) = 0.5590 \times 549 \text{ kW/ton}$

$NPLV_{adj} = 0.5390 \times 500 / (1.0228 \times 0.9970) = 0.5290 \times 490 \text{ kW/ton}$ [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 higher more than 32°F (0°C) and water-cooled positive displacement chilling packages with a condenser leaving fluid temperature less than 115°F (46°C) shall be in accordance with Table E 503.7.1(3) where 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 as follows 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 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 as follows in accordance with the following:

“Manufactured for nonstandard-size applications only not to be installed in new construction projects.” [ASHRAE 90.1:6.4.1.5.2]

E 503.4.5 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 a 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 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.
(2) The perimeter system heating and cooling supply is controlled by a thermostatic control(s) located within the zones(s) served by the system.

Exterior walls are considered to have different orientations where the directions 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 a temperature range or dead band of not less than 5°F (-15°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 an 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(A) through Section E 503.4.6.3(D).

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(A) 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(B) Setback Controls. Heating systems in climate zones 2 through zone 8 shall be equipped with controls that have the capability configured to automatically restart and temporarily operate the system as required to maintain zone temperatures above an adjustable heating setpoint adjustable down to 55°F (13°C) or lower of not less than 10°F (6°C) below the occupied heating setpoint. Cooling systems located in climate zones 1b, 2b, and 3b shall be equipped with controls that have the capability configured to automatically restart and temporarily operate the mechanical cooling system as required to maintain zone temperatures below an adjustable cooling setpoint adjustable up to 90°F (32°C) or higher of not less than 5°F (3°C) above the occupied cooling setpoint or to prevent high space humidity levels.

Exception: Radiant floor and ceiling heating systems 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(C) Optimum Start Controls. Individual heating and cooling air distribution systems with setback controls and DDC with a total design supply air capacity exceeding 10 000 ft³/min (1.7195 m³/s), served by one or more supply fans, 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 air 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(D) 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 nor does not include more than one floor. Each isolation area shall be equipped with isolation devices capable of automatically shutting 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(A), Automatic Shutdown. For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for a length of time while serving 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 where other zones are inoperative. [ASHRAE 90.1:6.4.3.4.3.4]

E 503.4.6.4 Ventilation System Controls. Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of being automatically closed during normal building operation and are interlocked to open in accordance with fire and smoke detection systems. [ASHRAE 90.1:6.4.3.4.1]

E 503.4.6.4(A) Shutoff Damper Controls. Outdoor air supply intake and exhaust systems shall be equipped with motorized dampers that will automatically shut where the systems or spaces served are not in use. Ventilation outdoor air, exhaust or relief dampers shall be capable of automatically shutting off during preoccupancy building warm-up, cooldown, and setback, except where ventilation reduces energy costs or where ventilation shall be supplied to be in accordance with the requirements of this code.

Exceptions:

1. Backdraft gravity (nonmotorized) dampers shall be permitted for exhaust and relief in buildings less than three stories above grade in height, and for ventilation air intakes and exhaust and relief dampers in buildings of any height located in climate zones 1 through zone 3. Backdraft 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]

E 503.4.6.4(B) Dampers Leakage. Where outdoor air supply, and exhaust or relief dampers are required by in Section E 503.4.6.4, they shall have a maximum leakage rate in accordance with Table E 503.4.6.4(B) where tested in accordance with AMCA 500 indicated in Table E 503.4.6.4(B). [ASHRAE 90.1:6.4.3.4.3]

E 503.4.6.4(C) Ventilation Fan Controls. Fans with motors greater than 0.75 hp (0.56 kW) shall have automatic controls in accordance with Section E 503.4.6.3(A) that are capable of shutting off fans where not required. Exception: HVAC systems intended to operate continuously. [ASHRAE 90.1:6.4.3.4.4]

<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>1, 2 any height</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>3 any height</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>4, 5b, 5c less than 3 stories</td>
<td>not allowed</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 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>

* 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].

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.
E 503.4.6.5 Enclosed Parking Garage Ventilation. Heated or 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. [ASHRAE 90.1:6.4.3.4.5]

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 ratio that exceeds 1500 square feet per horsepower (ft²/hp) (186.8 m²/kW) and do not utilize mechanical cooling or 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 HSPF ratings are in accordance with the requirements shown in Table E 503.7.1(2) and includes usage of an internal electric resistance heating. [ASHRAE 90.1:6.4.3.4.5]

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 shutting off the systems where outdoor air temperatures are above more than 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 shutting off the systems where the pavement temperature is above more than 50°F (10°C) and no precipitation is falling, and an automatic or manual control that will allow shutoff where the outdoor temperature is above 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) is required for spaces more than 500 square feet (46.45 m²) and with a design occupancy for ventilation of more than 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 4200 ft³/min (0.5662 3.5406 m³/s).
(4) Spaces where more than 75 percent of the supply space design outdoor airflow is required for makeup air that is exhausted from the space or rate minus a makeup or outgoing transfer air that is required for makeup air that is exhausted from other space(s) requirement is less than 1200 ft³/min (0.5663 m³/s).
(5) Spaces with one of the following occupancy categories in accordance with Chapter 4 or in ASHRAE 62.1: correctional cells; daycare sick-
rooms; science labs; barbers; beauty and nail salons; and bowling alley seating. [ASHRAE 90.1:6.4.3.9 6.4.3.8]

E 503.4.6.11 Single-Zone Variable-Air-Volume Controls. HVAC systems shall have variable airflow controls in accordance with the following:

1. Air handling and fan coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 3.6 hp (2.72 kW) shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands not more than 50 percent, the supply fan controls shall be able to reduce the airflow to not more than the larger of the following:
   a. One-half of the full fan speed.
   b. The volume of outdoor air required to comply with the ventilation requirements of ASHRAE 62.1.

2. Effective January 1, 2012, air conditioning equipment and air handling units with direct expansion cooling and a cooling capacity at AHRI conditions not less than 110,000 Btu/h (32 kW) that serve single zones shall have their supply fans controlled by two-speed motors or variable speed drives. At cooling demands not more than 50 percent, the supply fan controls shall be able to reduce the airflow to not more than the larger of the following:
   a. Two-thirds of the full fan speed.
   b. The volume of outdoor air required to comply with the ventilation requirements of ASHRAE 62.1.

E 503.4.6.12 503.4.6.10 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 503.4.7 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 (see ASHRAE 90.1). 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(A) 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(1) and Table E 503.7.2(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 need 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) need not be required to exceed R-2; those not exceeding 5 square feet (0.5 m²) need not be required to be insulated. [ASHRAE 90.1:6.4.4.1.2]

E 503.4.7.1(B) Piping Insulation. Piping shall be thermally insulated in accordance with Table E 503.7.2(2) 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, or natural gas piping).

4. Where heat gain or heat loss will not increase energy usage (such as liquid refrigerant piping).
E 503.4.7.1(C) Sensible Heating Panel
Thermally ineffective panel surfaces of sensible heating panels, including U-bends and headers, shall be insulated with not less than R-3.5. Adjacent building envelope insulation shall be permitted to be applied to this insulation value. [ASHRAE 90.1:6.4.4.1.4]

E 503.4.7.1(D) Radiant Floor Heating. The bottom surfaces of floor structures incorporating radiant heating shall be insulated not less than R-3.5. Adjacent building envelope insulation shall be permitted to be applied to this insulated value.

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 Ducts and Plenum Leakage. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A in accordance with Table E 503.4.7.2(1). [Table E 503.4.7.2(2) provides definitions of seal levels], as required to be in accordance with Section E 503.4.7.2(A), and with standard industry practice and SMACNA HVAC Duct Construction Standard, or ASHRAE 90.1. Openings for rotating shafts shall be sealed with bushings or devices that seal off air leakage. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified in accordance with UL 181A or UL 181B. Pressure-sensitive tape shall not be used as the primary sealant, unless it has been certified in accordance with that certification. (See note)

Notes:
- UL 181A or UL 181B is not applicable to metal-to-metal duct joints.
- Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod, or wire. Spiral lock seams in a round or flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that is capable of voiding the product listings shall not be required. Spiral lock seams shall be permitted to not be sealed. Duct pressure class ratings shall be designated in the design documents. [ASHRAE: 90.1:6.4.4.2.1]

### Table E 503.4.7.2(4)
<table>
<thead>
<tr>
<th>DUCT LOCATION</th>
<th>SUPPLY</th>
<th>EXHAUST</th>
<th>RETURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Unconditioned spaces</td>
<td>B</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>Conditioned spaces*</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

Notes:
- 1 See Table E 503.4.7.2(3) description of seal levels
- 2 Duct design static pressure classification
- 3 Includes indirectly conditioned spaces such as return air plenums

E 503.4.7.2(A) Duct Leakage Tests. Ductwork that is designed to operate at static pressures in excess of exceeding 3 inches water column (0.7 kPa) and ductwork located outdoors shall be leak-tested in accordance with SMACNA-016 industry-accepted test procedures. Representative sections totaling not less than 25 percent of the total installed duct area for the designated pressure class shall be tested. Duct systems with pressure ratings exceeding 3 inches water column (0.7 kPa) shall be identified on the drawings. Sections to be tested shall be selected by the building owner or designated representative of the building owner. Positive pressure leakage testing shall be acceptable for negative pressure ductwork. The permitted duct leakage shall be not more than the following calculations: [ASHRAE 90.1:6.4.4.2.2]:

\[ L_{max} = C_L P_{0.65} \]

Where:
- \(L_{max}\) maximum permitted leakage, in \((ft^3/min)/100 square feet duct surface area\).
- \(C_L\) Six duct leakage class, \((ft^3/min)/100 square feet duct surface area at 1 inch water column. Six for rectangular sheet metal, rectangular fibrous, and round flexible ducts. Three for round/flat oval sheet metal or fibrous glass ducts.\)
\[ P = \] test pressure, which shall be equal to the design duct pressure class rating, in inch water column \[ \text{based on ASHRAE 90.1:6.4.4.2.2} \]

For SI units: 1 cubic foot per minute = 0.00047 m³/s, 1 square foot = 0.0929 m², 1 inch water column = 0.249 kPa

E 503.4.7.2 (B) Duct Leakage Tests with Less than 3 inches Water Column. Ductwork that is designed to operate at static pressures less than 3 inches water column (0.7 kPa) located outdoors and within unconditioned space shall be leak tested in accordance with SMACNA 016. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

E 503.5 Prescriptive Path. Each cooling systems that have a fans shall include either an air or water economizer meeting the requirements of 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. Systems that include nonparticulate air treatment in accordance with ASHRAE 62.1.

3. Systems 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 with applicable codes or standards. In 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.

4. Systems that include a condenser heat recovery system with a minimum capacity in accordance with the IAPMO Green Plumbing & Mechanical Code Supplement Section E 503.5.10.1(B).

5. Systems that serve residential spaces where the system capacity is less than five times the requirement listed in Table E 503.5(1).

6. 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).

7. Systems expected to operate less than 20 hours per week.

8. Where the use of outdoor air for cooling will affect supermarket open refrigerated casework systems.

9. For comfort cooling where the cooling efficiency is not less than the efficiency improvement requirements in accordance with Table E 503.3.1 503.5(3).

(10) Systems primarily serving computer rooms where in accordance with the following:

(a) The total design cooling load of 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 not more 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.

(11) Dedicated systems for computer rooms where a minimum of 75 percent of the design load serves 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 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>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>COOLING CAPACITY WHERE AN ECONOMIZER IS REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a, 1b, 2a, 3a, 4a</td>
<td>No economizer requirement</td>
</tr>
<tr>
<td>2b, 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
E 503.5.1 Air Economizers. Air economizer systems shall be capable of 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 shall be capable of being sequenced 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 automatically reducing outdoor air intake to the design minimum outdoor air quantity where outdoor air intake will no longer reduce cooling energy usage. High-limit shutoff control types for specific climates shall be chosen from Table E 503.5.1.2(1). High-limit shutoff control settings for these control types shall be those listed in Table E 503.5.1.2(2) 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(B) through Section E 503.4.6.13. [ASHRAE 90.1:6.5.1.1.4]

E 503.5.2 Water Economizers. Water economizer systems shall be capable of cooling supply air by indirect evaporation and 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 where in which 100 percent of the expected system cooling load at the 40°F (4°C) dry bulb and or 35°F (2°C) wet bulb in accordance with Table E 503.5.2 is achieved using evaporative water economizers.

2. Systems primarily serving computer rooms with dry cooler water economizers that provide in which 100 percent of the expected system cooling load at the 35°F (2°C) dry bulb temperatures in accordance with Table E 503.5.2 is achieved with dry cooler water 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 using evaporative water economizers. [ASHRAE 90.1:6.5.1.2.1]

E 503.5.2.1 Maximum Pressure Drop. Precooling coils and water-to-water heat exchangers used as part of a water 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 90.1:6.5.1.2.1]

E 503.5.3 Integrated Economizer Control. Economizer systems shall be integrated with the mechanical cooling system and be capable of providing partial cooling even where additional mechanical cooling is required to meet 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...
### APPENDIX E

**HIGH-LIMIT SHUTOFF CONTROL SETTINGS FOR AIR ECONOMIZERS**

[ASHRAE 90.1: TABLE 6.5.1.1.3B]

<table>
<thead>
<tr>
<th>CONTROL DEVICE TYPE</th>
<th>ALLOWED ONLY IN CLIMATE ZONE AT LISTED SETPOINT</th>
<th>REQUIRED HIGH LIMIT (ECONOMIZER OFF WHEN WHERE):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry bulb temperature</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8, 1a, 2a, 3a, 4a</td>
<td>$T_{oa} &gt; 75^\circ F$</td>
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<tr>
<td></td>
<td></td>
<td>$T_{oa} &gt; 70^\circ F$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{oa} &gt; 65^\circ F$</td>
</tr>
<tr>
<td>Differential dry bulb temperature</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6a, 6b, 7, 8</td>
<td>$T_{oa} &gt; T_{ra}$</td>
</tr>
<tr>
<td>Fixed enthalpy with fixed dry-bulb temperature</td>
<td>All</td>
<td>$h_{oa} &gt; 28$ Btu/lb or $T_{oa} &gt; 75^\circ F$</td>
</tr>
</tbody>
</table>
| Electronic enthalpy | All | $(T_{oa},RH_{oa}) > A$ | Outdoor air temperature/RH exceeds the "$A" setpoint curve
| Differential enthalpy with fixed dry-bulb temperature | All | $h_{oa} > h_{ra}$ or $T_{oa} > 75^\circ F$ | Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds 75°F |
| Dew-point and dry-bulb temperatures | All | $DP_{oa} > 55^\circ F$ or $T_{oa} > 75^\circ F$ | Outdoor air dry bulb exceeds 75°F or outside dew point exceeds 55°F (65 gr/lb) |

For SI units: °C = (°F-32)/1.8, 1 British thermal unit per pound = 2326 J/kg, 1 grain = 0.0000648 kg

Notes:
1. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F (24°C) and 50 percent relative humidity. As an example, at approximately 6000 feet (1829 m) elevation, the fixed enthalpy limit is shall be approximately 30.7 Btu/lb (71 408 J/kg).
2. Setpoint "A" corresponds to a curve on the psychrometric chart that goes through a point at approximately 75°F (24°C) and 40 percent relative humidity and is nearly parallel to dry-bulb lines at low humidity levels and nearly parallel to enthalpy lines at high humidity levels. 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.

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**TABLE E 503.5.2**

**WATER ECONOMIZER SIZING DRY-BULB AND WET-BULB REQUIREMENTS FOR COMPUTER ROOMS**

[ASHRAE 90.1: TABLE 6.5.1.2.1]

<table>
<thead>
<tr>
<th>ZONE</th>
<th>EVAPORATIVE WATER ECONOMIZER</th>
<th>DRY COOLER WATER ECONOMIZER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRY BULB, °F</td>
<td>WET BULB, °F</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>Not Required</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>35.0</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>3</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>30.0</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>30.0</td>
</tr>
<tr>
<td>5</td>
<td>A</td>
<td>40.0</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>30.0</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
<td>35.0</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>30.0</td>
</tr>
<tr>
<td>7</td>
<td>—</td>
<td>30.0</td>
</tr>
<tr>
<td>8</td>
<td>—</td>
<td>30.0</td>
</tr>
</tbody>
</table>

For SI units: °C = (°F-32)/1.8
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]

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 503.5.5 Simultaneous Heating and Cooling Limitation. Zone thermostatic controls shall be provided to 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) Thirty percent of the zone design peak supply rate.

(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) Zones with DDC that comply with the following:

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### TABLE E 503.6.1.2(1)

**HIGH-LIMIT SHUTOFF CONTROL OPTIONS FOR AIR ECONOMIZERS**

[ASHRAE 90.1: TABLE 6.6.1.1.3A]

<table>
<thead>
<tr>
<th>CLIMATE ZONES</th>
<th>ALLOWED CONTROL TYPES</th>
<th>PROHIBITED CONTROL TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8</td>
<td>Fixed dry bulb, Differential dry bulb, Electronic enthalpy, Differential enthalpy, Dew point and dry bulb temperatures</td>
<td>Fixed enthalpy</td>
</tr>
<tr>
<td>4a, 2a, 3a, 4a</td>
<td>Fixed enthalpy, Electronic enthalpy, Differential enthalpy, Dew point and dry bulb temperatures</td>
<td>Fixed dry bulb, Differential dry bulb</td>
</tr>
<tr>
<td>5a, 6a</td>
<td>Fixed dry bulb, Differential dry bulb, Electronic enthalpy, Differential enthalpy, Dew point and dry bulb temperatures</td>
<td>—</td>
</tr>
</tbody>
</table>

* Electronic enthalpy controllers are devices that use a combination of humidity and dry bulb temperature in their switching algorithm.

---
APPENDIX E

(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, 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.
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) Airflow between dead band and full heating or full cooling shall be modulated.

(d) The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint while the airflow is maintained at the dead band flow rate.

(e) 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 with Section E 503.5.11.2.

4. Zones where not less than 75 percent of the energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (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 floor shall not supply heating air more than 20°F (−7°C) above the space temperature setpoint.

Exceptions:

1. Laboratory exhaust systems in accordance with Section E 503.5.11.2.
2. During reoccupancy 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(A) through Section E 503.5.5.2(C). [ASHRAE 90.1:6.5.2.2]

E 503.5.5.2(A) 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(B) Two-Pipe Changeover System. Systems that use a common distribution system to supply both heated and chilled water are acceptable provided where in accordance with the following requirements are met:

1. The system is designed to allow a dead band between changeover from one mode to the other of not less than 15°F (−9°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(C) 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 providing a heat pump water supply temperature dead band of not less than 20°F (−7°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 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 tower is used directly in the heat pump loop, an automatic valve shall be installed to bypass heat pump water flow around the tower. Where an open-circuit 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 (11.1°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 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 80 000 Btu/h (19 23.4 kW) and is capable of unloading 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) or less. 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 the building includes site-recovered or site-solar energy source that provide energy 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 75 90 percent of the annual energy for reheating or for providing warm air in mixing systems is provided from a site-recovered (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 503.5.5.4 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 90.1:6.4.2.6 6.5.2.4.1]

E 503.5.6 Air System Design and Control. HVAC 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 and through Section E 503.5.6.4 503.5.6.5. [ASHRAE 90.1:6.5.3]

E 503.5.6.1 Fan System Power Limitation and Efficiency. Each HVAC systems 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. Single-zone variable-air-volume systems shall comply with the constant-volume fan power limitation. [ASHRAE 90.1:6.5.3.1.1]

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(A) Motor Nameplate Horsepower. For a fan, the selected fan motor shall be not larger than the first available motor size greater 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 with 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. [ASHRAE 90.1:6.5.3.1.2]

E 503.5.6.2 VAV Fan Control (Including Systems Using Series Fan Power Boxes). Individual VAV fans with motors 10 hp (7.5 kW) and larger shall meet one of the following:
(1) The fan shall be driven by a mechanical or electrical variable-speed drive.
(2) The fan shall be a vane axial fan with variable-pitch blades.
(3) The fan shall have other controls and devices that will result in fan motor demand of not more than 30 percent of design wattage at 50 percent of design air volume where static pressure setpoint.
equals one-third of the total design static pressure, based on manufacturer's certified fan data.  
[ASHRAE 90.1: 6.5.3.2.1]

**E 503.5.6.2 Fan Airflow Control.** Cooling systems listed in Table E 503.5.6.2 shall be designed to vary the indoor fan airflow as a function of load and shall be in accordance with the following:

(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

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**TABLE E 503.5.6.1(1)**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>LIMIT</th>
<th>CONSTANT VOLUME</th>
<th>VARIABLE VOLUME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Fan System</td>
<td>Allowable Nameplate Motor (hp)</td>
<td>$hp \leq CFM_S \times 0.0011$</td>
<td>$hp \leq CFM_S \times 0.0015$</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>
<td>$bhp \leq CFM_S \times 0.0013 + A$</td>
</tr>
</tbody>
</table>

For SI units: 1 horsepower = 0.746 kW, 1 cubic foot per minute = 0.00047 m$^3$/s

* Where:

$CFM_S$ = the maximum design supply airflow rate to conditioned spaces served by the system in cubic feet per minute (m$^3$/s)

$hp$ = the maximum combined motor nameplate horsepower (kW)

$bhp$ = the maximum combined fan brake horsepower (kW)

$A$ = sum of $(PD \times CFM_D)/4131$

Where:

$PD$ = 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 (m$^3$/s)

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**TABLE E 503.5.6.1(2)**

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully ducted return, exhaust, or both air systems</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>(2.2 x energy recovery effectiveness) + 0.5 in w.c. for each airstream</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**

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems without central cooling device</td>
<td>−0.6 in. wc</td>
</tr>
<tr>
<td>Systems without central heating device</td>
<td>−0.3 in. wc</td>
</tr>
<tr>
<td>Systems with central electric resistance heat</td>
<td>−0.2 in. wc</td>
</tr>
</tbody>
</table>

For SI units: 1 inch water column = 0.249 kPa, 1 foot = 304.8 mm
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 units, including DX cooling units and chilledwater 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 Section E 503.5 through Section E 503.5.4.1 shall have not less than 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 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 90.1:6.5.3.2.1]

E 503.5.6.2(A) VAV Static Pressure Sensor Location. Static pressure sensors used to control VAV fans shall be placed in a position located such that the controller setpoint is not greater than one-third 1.2 inches water column (0.30 kPa) the total design fan static pressure, except for systems with zone reset control in accordance with Section E 503.5.6.2(B). Where this results in the sensor being located downstream of major duct splits, multiple sensors shall be installed in each major branch to ensure that static pressure is maintained in each.

Exceptions:

Systems that are in accordance with section E 503.5.6.2(B). [ASHRAE 90.1:6.5.3.2.2]

E 503.5.6.2(B) Setpoint Reset. For systems with DDC of individual zone reporting to the central control panel, static pressure setpoint shall be reset based on the zone requiring the most pressure (e.g., 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]

E 503.5.6.3 Multiple-Zone VAV System Ventilation Optimization Control. Multiple-zone VAV systems with DDC 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.

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 required to have the exhaust air energy recovery in accordance with Section E 503.5.10.

(3) 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

<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</td>
<td>1/1/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥75,000</td>
<td>1/1/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥65,000</td>
<td>1/1/2016</td>
</tr>
<tr>
<td>Chilled-water and</td>
<td>≥5</td>
<td>Any</td>
<td>1/1/2014</td>
</tr>
<tr>
<td>evaporative cooling</td>
<td>≥2/3</td>
<td>Any</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
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 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 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 or site solar energy sources. [ASHRAE 90.1:6.5.3.4]

E 503.5.6.5 Fractional Horsepower Fan Motors. Motors for fans that are \( \frac{1}{4} \text{hp} \) (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: 6.5.3.5]

E 503.5.7 Hydronic System Design and Control. HVAC hydronic systems having a total pump system...
**APPENDIX E**

power exceeding 10 hp (7.5 kW) shall be in accordance with Section E 503.5.7.1 through Section E 503.5.7.4. 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 E 503.5.7**

**BOILER TURNDOWN**

[ASHRAE 90.1: TABLE 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.** HVAC pumping systems having a total pump system power exceeding 10 hp (7.5 kW) that include 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 reducing pump flow rates to 50 percent or less of the design flow rate. Individual chilled-water pumps serving variable-flow systems having motors exceeding 5 hp (3.7 kW) shall have controls, devices, or both (such as variable-speed control) 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 be in accordance with this section, and DDC controls are used, the setpoint shall be reset downward based on valve positions until one valve is nearly wide open.

**Exceptions:**

1. Systems where the minimum flow is less than the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system, such as chillers, and where total pump system power is 75 hp (55.9 kW) or less.
2. Systems that include not more than three control valves. [ASHRAE 90.1:6.5.4.42]

**E 503.5.7.2 Pump Chiller and Boiler Isolation.** Where a chilled-water plant includes more than one chiller, provisions shall be made so that the fluid flow in the chiller plant is capable of being automatically reduced shut off, correspondingly, where the chiller is shut down. Chillers referred to in this section, 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(A) Boiler Isolation.** Where a boiler plant includes more than one boiler, provisions shall be made so that the flow through the boiler plant is capable of being automatically reduced shut off, correspondingly, 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 90.1:6.5.4.3.2]

**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.

**Exceptions:**

1. Where the supply temperature reset controls cannot be not capable of being implemented without causing improper operation of heating, cooling, humidifying, or dehumidifying systems.
2. Hydronic systems, such as those required by in Section E 503.5.7.1 that use variable flow to reduce pumping energy. [ASHRAE 90.1:6.5.4.3.1 6.5.4.4]

**E 503.5.7.4 Hydronic (Water Loop) Heat Pump and Water-Cooled Unitary Air Conditioners–Systems.** Hydronic heat pumps and water-cooled unitary air-conditioners shall have a two-position automatic valve interlocked to shut off water flow where the compressor is off.

**Exception:** Units employing water economizers. [ASHRAE 90.1:6.5.4.4.1 6.5.4.5.1]

**E 503.5.7.4(A) 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 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 designed such that the design flow rate in a pipe segment does not exceed the values listed in Table E 503.5.7.5 for the appropriate total annual hours of operation. Pipe size selections for systems that operate under variable flow conditions, such as 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. [ASHRAE 90.1:6.5.4.5]

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 is not in the critical circuit at design conditions and is not predicted to be in the critical circuit during 30 percent or more of operating hours.
2. Piping systems that have not more than the total pressure drop of 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. Each fan powered by a motor of 7.5 hp (5.59 kW) or larger shall have the capability to operate at two-thirds of full speed or less, and shall have controls that automatically change 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.
2. Condenser fans serving flooded condensers.
3. Installations located in climate zone 1 and zone 2.
4. Up to one-third of the fans on a condenser or tower with multiple fans, where the lead fans are in accordance with the speed control requirement. [ASHRAE 90.1:6.5.5.2.1]

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 meet the energy efficiency requirement for axial fan open-circuit cooling towers listed 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 503.5.10 Exhaust Air Energy Recovery. A fan system shall have an energy recovery system where the system’s supply 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.

### Table E 503.5.7.5

**Piping System Design Maximum Flow Rate (gallons per minute)**

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE, (inches)</th>
<th>OPERATING HOURS/YEAR</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
<th>OTHER</th>
<th>VARIABLE FLOW/ VARIABLE SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤2000 HOURS/YEAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2½</td>
<td>120</td>
<td>180</td>
<td>85</td>
<td>130</td>
<td>68</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>270</td>
<td>140</td>
<td>210</td>
<td>110</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>530</td>
<td>260</td>
<td>400</td>
<td>210</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>410</td>
<td>620</td>
<td>310</td>
<td>470</td>
<td>250</td>
<td>370</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>740</td>
<td>1100</td>
<td>570</td>
<td>860</td>
<td>440</td>
<td>680</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1200</td>
<td>1800</td>
<td>900</td>
<td>1400</td>
<td>700</td>
<td>1100</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1800</td>
<td>2700</td>
<td>1300</td>
<td>2000</td>
<td>1000</td>
<td>1600</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>2500</td>
<td>3800</td>
<td>1900</td>
<td>2900</td>
<td>1500</td>
<td>2300</td>
<td></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>
<td>9.5 ft/s</td>
<td>5.0 ft/s</td>
<td>7.5 ft/s</td>
<td></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
Energy recovery systems required by this section shall have 50 percent or more energy recovery effectiveness. Fifty percent energy recovery effectiveness shall be the change in the enthalpy of the outdoor air supply equal to 50 percent of the difference between the outdoor air and return 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 meeting 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) Systems exhausting toxic, flammable, paint, corrosive fumes, or dust.
(4) Commercial kitchen hoods used for collecting and removing grease vapors and smoke.
(5) Where more than 60 percent of the outdoor air heating energy is provided from site-recovered or site-solar energy.

(6) Heating systems energy recovery in climate zones 1 and zone 2.
(7) Cooling systems energy recovery in climate zones 3c, 4e, 5b, 5c, 6b, 7, and 8.
(8) Where the largest exhaust source of air exhausted at a single location at the building exterior is less than 75 percent of the design outdoor airflow rate.
(9) Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
(10) Systems expected to operate less than 20 hours or less per week at the outdoor air percentage in accordance with Table E 503.5.10(1). [ASHRAE 90.1:6.5.6.1]

### E 503.5.10.1 Heat Recovery for Service Water Heating

Heat recovery shall comply with Section E 503.5.10.1(A) and Section E 503.5.10.1(B)

#### E 503.5.10.1(A) 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:

#### TABLE E 503.5.10(1)

**EXHAUST AIR ENERGY RECOVERY REQUIREMENTS FOR VENTILATION SYSTEMS OPERATING LESS THAN 8000 HOURS PER YEAR**

*ASHRAE 90.1: TABLE 6.5.6.1-1*

<table>
<thead>
<tr>
<th>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>3B, 3C, 4B, 4C, 5B</td>
<td>≤10% and &lt;20%</td>
<td>≤20% and &lt;30%</td>
</tr>
<tr>
<td>1B, 2B, 5C</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>6B</td>
<td>≥28 000</td>
<td>≥26 500</td>
</tr>
<tr>
<td>1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥26 000</td>
<td>≥24 000</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥4500</td>
<td>≥4000</td>
</tr>
</tbody>
</table>

*For SI units: 1 cubic foot per minute = 0.00047 m³/s
*NR = No Requirement

#### TABLE E 503.5.10(2)

**EXHAUST AIR ENERGY RECOVERY REQUIREMENTS FOR VENTILATION SYSTEMS OPERATING NOT LESS THAN 8000 HOURS PER YEAR**

*ASHRAE 90.1: TABLE 6.5.6.1-2*

<table>
<thead>
<tr>
<th>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>1B, 2B, 3B, 4C, 5C</td>
<td>≥19 500</td>
<td>≥9000</td>
<td>≥5000</td>
<td>≥4000</td>
<td>≥3000</td>
<td>≥1500</td>
<td>≥0</td>
<td>&gt;0</td>
</tr>
<tr>
<td>1A, 2A, 3A, 4B, 5B</td>
<td>≥2500</td>
<td>≥2000</td>
<td>≥1000</td>
<td>≥500</td>
<td>≥0</td>
<td>≥0</td>
<td>≥0</td>
<td>≥0</td>
</tr>
<tr>
<td>4A, 5A, 6A, 6B, 7</td>
<td>≥0</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>≥0</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>&gt;0</td>
</tr>
</tbody>
</table>

*For SI units: 1 cubic foot per minute = 0.00047 m³/s
*NR—Not required
(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(B) 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.
(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 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, 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 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 90.1:6.5.7.1.1]

E 503.5.11.1(A) Conditioned Supply Air. Conditioned supply air delivered to a space with a kitchen hood 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 hood exhaust flow minus the available transfer air from adjacent spaces. Available transfer air is that portion of outdoor ventilation air not required to satisfy other exhaust needs, such as restrooms, and not required to maintain pressurization of adjacent spaces.

[ASHRAE 90.1:6.5.7.1.2]

E 503.5.11.2 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 90.1:6.5.7.1.3]

E 503.5.11.2(A) 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 replacement air is transfer air that would otherwise be exhausted.
(2) Demand ventilation system(s) provide 75 percent or more of the exhaust air. Such systems shall be capable of providing 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 with a sensible heat recovery effectiveness of 40 percent or more on 50 percent or more of the total exhaust airflow. [ASHRAE 90.1:6.5.7.1.4]

E 503.5.11.2(B) Performance Testing. An approved field test method shall be used to evaluate design air flow rates and demonstrate proper performance.

TABLE E 503.5.11.2
MAXIMUM NET EXHAUST FLOW RATE, CFM PER LINEAR FOOT OF HOOD LENGTH
[ASHRAE 90.1: TABLE 6.5.7.1.3]

<table>
<thead>
<tr>
<th>TYPE OF HOOD</th>
<th>LIGHT DUTY EQUIPMENT</th>
<th>MEDIUM DUTY EQUIPMENT</th>
<th>HEAVY DUTY EQUIPMENT</th>
<th>EXTRA HEAVY DUTY EQUIPMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted canopy</td>
<td>140</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Single island</td>
<td>280</td>
<td>350</td>
<td>420</td>
<td>490</td>
</tr>
<tr>
<td>Double island (per side)</td>
<td>175</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>175</td>
<td>175</td>
<td>Not allowed</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Backshelf/Pass-over</td>
<td>210</td>
<td>210</td>
<td>280</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>

For SI units: 1 foot = 304.8 mm, 1 cubic foot per minute = 0.00047 m³/s
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(A), additional performance testing shall be provided to demonstrate proper capture and containment at minimum airflow. [ASHRAE 90.1:6.5.7.1.5]

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) or more shall include not less than one of the following features:

(1) VAV laboratory exhaust and room supply systems capable of reducing exhaust airflow rates, makeup airflow rates, or both shall incorporate a heat recovery system to precondition makeup air from laboratory exhaust and shall be in accordance with the following:

\[ A + Bx(E/M) \geq 50\% \]  \hspace{1cm} (Equation E 503.5.11.3)

Where:

\( A \) = Percentage that the exhaust and makeup airflow rates are capable of being reduced from design conditions.
\( B \) = Percentage sensible recovery effectiveness.
\( E \) = 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 required to have minimum circulation rates to be in accordance with the applicable codes or standards shall be capable of reducing zone exhaust and makeup airflow rates to the regulated minimum circulation values, or the minimum required to maintain pressurization relationship requirements. Nonregulated zones shall be capable of reducing 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 (47°F-47°C) below room setpoint, cooled to not less than 3°F (48°C) above room setpoint, no humidification is added, and no simultaneous heating and cooling are used for dehumidification control. [ASHRAE 90.1:6.5.7.2]

E 503.5.12 Radiant Heating Systems. Radiant heating shall be used where 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 enclosed space heating shall be in accordance with the governing provisions of 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.

Exception: Unitary packaged systems with cooling capacities not greater than 90 000 Btu/h (26.4 kW). [ASHRAE 90.1:6.5.9]

<table>
<thead>
<tr>
<th>RATED CAPACITY</th>
<th>MAXIMUM HOT GAS BYPASS CAPACITY (percent of total capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤240,000 Btu/h</td>
<td>50 15%</td>
</tr>
<tr>
<td>&gt;240,000 Btu/h</td>
<td>50 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.
(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. [ASHRAE 90.1:6.7.1]

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 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 include an operating and maintenance manual for that all lighting equipment and lighting controls, and a copy shall 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. The following requirements Section E 503.6.5.1 through Section E 503.6.5.4(A) 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 (see ASHRAE 90.1) 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 setpoints. [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(A) 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(B) 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(A) 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, and duct insulation shall comply with Section E 503.7.2, and pipe insulation shall comply with Section E 503.7.3.

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**TABLE E 503.8.1**

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>PUE*</th>
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<tbody>
<tr>
<td>1A</td>
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<tr>
<td>2A</td>
<td>1.49</td>
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<td>4C</td>
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<td>5C</td>
<td>1.36</td>
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<td>1.32</td>
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<td>8</td>
<td>1.30</td>
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</table>

*PUE₀ and PUE₁ shall not include energy for battery charging.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR 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/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
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<td></td>
<td>Single Package</td>
<td>13.0 SEER (before 1/20/15) 14 SEER (as of 1/1/2015)</td>
<td></td>
</tr>
<tr>
<td>Through-the-wall, air cooled</td>
<td>≤30,000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>12.0 SEER</td>
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<td>Single Package</td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Small duct high velocity, air cooled</td>
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<td>Split System</td>
<td>11.0 SEER</td>
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<td>Electric resistance (or none)</td>
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<td></td>
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<td></td>
<td>Split system and single package</td>
<td>11.4 IEER (before 1/1/2016) 12.9 IEER (as of 1/1/2016)</td>
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<td>All other</td>
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<td>Split system and single package</td>
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<td>&lt;760,000 Btu/h</td>
<td>All other</td>
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<td>10.0 EER</td>
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<td>Air conditioners, water cooled</td>
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<td>≥65,000 Btu/h</td>
<td>All other</td>
<td>Split system and single package</td>
<td>11.5 EER (before 6/1/2011) 12.1 EER (as of 6/1/2011) 11.7 IEER (before 6/1/2011) 12.3 IEER (as of 6/1/2011) (before 1/1/2016) 13.9 IEER (as of 1/1/2016)</td>
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### Table E 503.7.1(1) (continued)

**ELECTRONICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS**

**MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1-07: TABLE 6.8.1A-1]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY¹</th>
<th>TEST PROCEDURE²</th>
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<td>Air conditioners, water cooled</td>
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<td>12.5 EER (as of 6/1/2011)</td>
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<td>All other</td>
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<td>12.5 EER (as of 6/1/2011) (as of 1/1/2016)</td>
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<td>13.7 IEER (as of 1/1/2016)</td>
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<td>Air conditioners, water cooled</td>
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<td>Electric resistance (or none)</td>
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<td>11.0 EER (before 6/1/2011)</td>
<td>12.4 EER (as of 6/1/2011)</td>
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<td>12.4 IEER (as of 6/1/2011) (before 1/1/2016)</td>
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<td>13.4 IEER (as of 1/1/2016)</td>
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<td>≥760 000 Btu/h</td>
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<td>Split system and single package</td>
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<td>12.2 EER (as of 6/1/2011)</td>
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<td>13.5 IEER (as of 1/1/2016)</td>
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<td>All other</td>
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<td>10.8 EER (before 6/1/2011)</td>
<td>12.0 EER (as of 6/1/2011)</td>
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<tr>
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<td>10.9 IEER (before 6/1/2011)</td>
<td>12.2 IEER (as of 6/1/2011) (before 1/1/2016)</td>
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<td>13.3 IEER (as of 1/1/2016)</td>
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<td>Air conditioners, evaporatively cooled</td>
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<td>12.3 IEER</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></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>Split system and single package</td>
<td>11.5 EER (before 6/1/2011)</td>
<td>12.1 EER (as of 6/1/2011)</td>
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<td>11.7 IEER (before 6/1/2011)</td>
<td>12.3 IEER (as of 6/1/2011)</td>
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<td>Split system and single package</td>
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<td>11.5 IEER (before 6/1/2011)</td>
<td>12.1 IEER (as of 6/1/2011)</td>
</tr>
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</table>
### TABLE E 503.7.1(1) (continued)

#### ELECTRONICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

**MINIMUM EFFICIENCY REQUIREMENTS**

**[ASHRAE 90.1-07: TABLE 6.8.1A-1]**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY</th>
<th>TEST PROCEDURE&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, evaporatively cooled</td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER (before 6/1/2011)</td>
<td>AHRI 340/360</td>
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<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011)</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>Split system and single package</td>
<td>11.0 EER (before 6/1/2011)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥760 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER (before 6/1/2011)</td>
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<tr>
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<td>All other</td>
<td>Split system and single package</td>
<td>10.8 EER (before 6/1/2011)</td>
<td></td>
</tr>
<tr>
<td>Condensing units, air cooled</td>
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<td>–</td>
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<td>Condensing units, water cooled</td>
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<td>–</td>
<td>13.5 EER 14.0 IEER</td>
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<tr>
<td>Condensing units, water or evaporatively cooled</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>–</td>
<td>13.0 (before 6/1/2011) 13.5 EER (as of 6/1/2011) 13.6 IEER (as of 6/1/2011) 14.0 IEER (as of 6/1/2011)</td>
<td></td>
</tr>
</tbody>
</table>

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

**Notes:**

<sup>1</sup> IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.

<sup>2</sup> ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.

<sup>3</sup> Single-phase, air-cooled air conditioners less than 65 000 Btu/h (19 kW) are regulated by NAECA. SEER values shall be those set by NAECA.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>HEATING SECTION TYPE</th>
<th>SUBCATEGORY FOR RATING CONDITION</th>
<th>MINIMUM EFFICIENCY¹</th>
<th>TEST PROCEDURE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>13.0 SEER (before 1/1/2015) 14 SEER (as of 1/1/2015)</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>Split system and single package</td>
<td>11.0 EER 11.2 IEER (before 1/1/2016) 12.2 IEER (as of 1/1/2016)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and &lt;240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>10.4 EER 10.5 IEER (before 1/1/2016) 11.4 IEER (as of 1/1/2016)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>9.3 EER 9.4 IEER (before 1/1/2016) 0.4 IEER (as of 1/1/2016)</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td>Through-the-wall, air cooled, (cooling mode)</td>
<td>≤30 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>12.0 SEER</td>
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</tr>
<tr>
<td>Small duct high velocity, air cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>Split System</td>
<td>11.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Water source 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, groundwater source (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, groundwater 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 source 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>Groundwater source 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>
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<tr>
<td>Ground source 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>
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</tr>
<tr>
<td>EQUIPMENT TYPE</td>
<td>SIZE CATEGORY</td>
<td>HEATING SECTION TYPE</td>
<td>SUBCATEGORY FOR RATING CONDITION</td>
<td>MINIMUM EFFICIENCY1</td>
<td>TEST PROCEDURE2</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>---------------------</td>
<td>----------------------</td>
<td>----------------------------------</td>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Air cooled (heating mode)</td>
<td>&lt;65 000 Btu/h²</td>
<td>–</td>
<td>Split system</td>
<td>7.7 HSPF (before 1/1/2015)</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and</td>
<td>–</td>
<td>Single package</td>
<td>8.2 HSPF (as of 1/1/2015)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>–</td>
<td>Split system</td>
<td>7.4 HSPF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>Single package</td>
<td>7.4 HSPF</td>
<td></td>
</tr>
<tr>
<td>Through-the-wall, air cooled, (heating mode)</td>
<td>≤30 000 Btu/h²</td>
<td>–</td>
<td>Split system</td>
<td>7.4 HSPF</td>
<td></td>
</tr>
<tr>
<td>Small duct high velocity, air cooled</td>
<td>&lt;65,000 Btu/h²</td>
<td>–</td>
<td>Split system</td>
<td>6.8 HSPF</td>
<td></td>
</tr>
<tr>
<td>(heating mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water to air, water loop source</td>
<td>&lt;135 000 Btu/h</td>
<td>–</td>
<td>68°F entering water</td>
<td>4.2 4.3 COP</td>
<td>ISO 13256-1</td>
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<tr>
<td>(heating mode)</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.3 COP</td>
<td></td>
</tr>
<tr>
<td>Water to air, ground-water source</td>
<td>&lt;135 000 Btu/h</td>
<td>–</td>
<td>50°F entering water</td>
<td>2.6 3.7 COP</td>
<td></td>
</tr>
<tr>
<td>(heating mode)</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>17°F db/15°F wb outdoor air</td>
<td>2.25 COP</td>
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<tr>
<td>Brine to air, ground-source loop</td>
<td>&lt;135 000 Btu/h</td>
<td>–</td>
<td>32°F entering water</td>
<td>2.4 3.2 COP</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>(heating mode)</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.2 COP</td>
<td></td>
</tr>
<tr>
<td>Water source water to water, water loop</td>
<td>&lt;135 000 Btu/h</td>
<td>–</td>
<td>68°F entering water</td>
<td>3.7 COP</td>
<td></td>
</tr>
<tr>
<td>(heating mode)</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>17°F db/15°F wb outdoor air</td>
<td>2.05 COP</td>
<td></td>
</tr>
<tr>
<td>Groundwater source</td>
<td>&lt;135 000 Btu/h</td>
<td>–</td>
<td>50°F entering water</td>
<td>3.1 COP</td>
<td>ISO 13256-2</td>
</tr>
<tr>
<td>Water to water, to groundwater</td>
<td>≥135 000 Btu/h</td>
<td>–</td>
<td>32°F entering water</td>
<td>2.5 COP</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
2. ASHRAE 90.1 contains a complete specification of the referenced test procedure including the referenced year version of the test procedure.
3. Single-phase air-cooled heat pumps less than 65 000 Btu/h (19 kW) are regulated by NAECA. SEER and HSPF values shall be those set by NAECA.
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNIT</th>
<th>PATH A</th>
<th>PATH B</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-Cooled Chillers</td>
<td>≤150 tons</td>
<td>EER</td>
<td>≥0.562</td>
<td>≥12.500</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>≥150 tons</td>
<td>EER</td>
<td>≥0.562</td>
<td>≥12.500</td>
<td>NA</td>
</tr>
<tr>
<td>Air-cooled, without condenser, electrically operated</td>
<td>All capacities</td>
<td>EER</td>
<td>Air-cooled chillers without condenser shall be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-cooled, electrically operated, reciprocating</td>
<td>All capacities</td>
<td>kW/ton</td>
<td>Reciprocating units shall comply with water-cooled positive displacement efficiency requirements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤75 tons</td>
<td>kW/ton</td>
<td>≤0.780</td>
<td>≤0.630</td>
<td>≤0.300</td>
</tr>
<tr>
<td></td>
<td>&gt;75 tons and ≤150 tons</td>
<td>kW/ton</td>
<td>≤0.775</td>
<td>≤0.645</td>
<td>≤0.700</td>
</tr>
<tr>
<td></td>
<td>&gt;150 tons and ≤300 tons</td>
<td>kW/ton</td>
<td>≤0.680</td>
<td>≤0.580</td>
<td>≤0.718</td>
</tr>
<tr>
<td></td>
<td>&gt;300 tons</td>
<td>kW/ton</td>
<td>≤0.620</td>
<td>≤0.540</td>
<td>≤0.630</td>
</tr>
<tr>
<td>Water-cooled, electrically operated, positive displacement, centrifugal</td>
<td>≤150 tons</td>
<td>kW/ton</td>
<td>≤0.631</td>
<td>≤0.596</td>
<td>≤0.639</td>
</tr>
<tr>
<td></td>
<td>&gt;150 tons and ≤300 tons</td>
<td>kW/ton</td>
<td>≤0.614</td>
<td>≤0.596</td>
<td>≤0.639</td>
</tr>
<tr>
<td></td>
<td>&gt;300 tons and ≤600 tons</td>
<td>kW/ton</td>
<td>≤0.576</td>
<td>≤0.540</td>
<td>≤0.600</td>
</tr>
<tr>
<td></td>
<td>&gt;600 tons</td>
<td>kW/ton</td>
<td>≤0.572</td>
<td>≤0.539</td>
<td>≤0.590</td>
</tr>
<tr>
<td>Air-cooled absorption single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.600</td>
<td>NR</td>
<td>NA</td>
</tr>
<tr>
<td>Water-cooled absorption single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.700</td>
<td>NR</td>
<td>NA</td>
</tr>
<tr>
<td>Absorption double effect, indirect-fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000</td>
<td>≥1.050</td>
<td>NA</td>
</tr>
<tr>
<td>Absorption double effect, direct-fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000</td>
<td>≥1.000</td>
<td>NA</td>
</tr>
</tbody>
</table>

Notes:
1 The centrifugal chiller equipment requirements after adjustment in accordance with Section E503.4.1 shall not apply to chillers where the design leaving evaporator temperature is less than 36°F (2°C). The requirements shall not apply to positive displacement chillers with design leaving fluid temperatures 32°F (0°C) or less. The requirements shall not apply to absorption chillers with design leaving fluid temperatures less than 40°F (4°C).
2 ASHRAE 90.1 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
3 Compliance with this supplement can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV shall be met to fulfill the requirements of Path A or Path B.
4 NA means that this requirement is not applicable and cannot be used for compliance.
5 NR means that there are no minimum requirements for this category.

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW
<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SIZE CATEGORY</th>
<th>UNITS</th>
<th>EFFECTIVE 1/1/2010</th>
<th>EFFECTIVE 1/1/2015</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Path A</td>
<td>Path B</td>
<td></td>
</tr>
<tr>
<td>Air-cooled chillers</td>
<td>&lt;150 tons</td>
<td>EER</td>
<td>≥9.562 FL</td>
<td>≥10.100 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥150 tons</td>
<td>EER</td>
<td>≥9.562 FL</td>
<td>≥10.100 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥12,500 IPLV</td>
<td>≥13,700 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥12,750 IPLV</td>
<td>≥14,000 IPLV</td>
<td></td>
</tr>
<tr>
<td>Air-cooled without condenser, electrically operated</td>
<td>All capacities</td>
<td>EER</td>
<td>≥10.100 FL</td>
<td>≥9.700 FL</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>≥12,750 IPLV</td>
<td>≥14,000 IPLV</td>
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</tr>
<tr>
<td>Water-cooled, electrically operated positive displacement</td>
<td></td>
<td>kW/ton</td>
<td>≤0.780 FL</td>
<td>≤0.750 FL</td>
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</tr>
<tr>
<td></td>
<td>&lt;75 tons</td>
<td></td>
<td>≤0.630 IPLV</td>
<td>≤0.600 IPLV</td>
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</tr>
<tr>
<td></td>
<td>≥75 tons and</td>
<td></td>
<td>≤0.775 FL</td>
<td>≤0.790 FL</td>
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</tr>
<tr>
<td></td>
<td>&lt;150 tons</td>
<td></td>
<td>≤0.615 IPLV</td>
<td>≤0.586 IPLV</td>
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</tr>
<tr>
<td></td>
<td>≥150 tons and</td>
<td></td>
<td>≤0.680 FL</td>
<td>≤0.660 FL</td>
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<tr>
<td></td>
<td>&lt;300 tons</td>
<td></td>
<td>≤0.580 FL</td>
<td>≤0.540 IPLV</td>
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<tr>
<td></td>
<td>≥300 tons and</td>
<td></td>
<td>≤0.620 FL</td>
<td>≤0.610 FL</td>
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</tr>
<tr>
<td></td>
<td>&lt;600 tons</td>
<td></td>
<td>≤0.540 IPLV</td>
<td>≤0.520 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥600 tons</td>
<td></td>
<td>≤0.620 FL</td>
<td>≤0.560 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.540 FL</td>
<td>≤0.490 IPLV</td>
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<tr>
<td></td>
<td></td>
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<td>≤0.620 FL</td>
<td>≤0.560 IPLV</td>
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<td>≤0.540 FL</td>
<td>≤0.490 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.620 FL</td>
<td>≤0.550 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.540 FL</td>
<td>≤0.380 IPLV</td>
<td></td>
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<tr>
<td>Water cooled, electrically operated centrifugal</td>
<td>≥150 tons</td>
<td>kW/ton</td>
<td>≤0.634 FL</td>
<td>≤0.639 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥300 tons</td>
<td></td>
<td>≤0.596 IPLV</td>
<td>≤0.540 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥400 tons</td>
<td></td>
<td>≤0.596 IPLV</td>
<td>≤0.540 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥600 tons</td>
<td></td>
<td>≤0.576 FL</td>
<td>≤0.600 FL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.549 IPLV</td>
<td>≤0.500 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.576 FL</td>
<td>≤0.560 FL</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td>≤0.549 IPLV</td>
<td>≤0.500 IPLV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤0.570 FL</td>
<td>≤0.590 FL</td>
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<tr>
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<td></td>
<td></td>
<td>≤0.539 IPLV</td>
<td>≤0.400 IPLV</td>
<td></td>
</tr>
<tr>
<td>Air-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.600 FL</td>
<td>≥0.600 FL</td>
<td></td>
</tr>
<tr>
<td>Water-cooled absorption, single effect</td>
<td>All capacities</td>
<td>COP</td>
<td>≥0.700 FL</td>
<td>≥0.700 FL</td>
<td></td>
</tr>
<tr>
<td>Absorption double effect, indirect fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000 FL</td>
<td>≥1.000 FL</td>
<td></td>
</tr>
<tr>
<td>Absorption double effect, direct fired</td>
<td>All capacities</td>
<td>COP</td>
<td>≥1.000 FL</td>
<td>≥1.000 FL</td>
<td></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 in accordance with 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 requirements shall be met or exceeded to comply with this appendix. When there is a Path B, compliance shall be permitted to be 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 shall be permitted to be used.
5. FL shall be the full-load performance requirements, and IPLV shall be for the part-load performance requirements.
### TABLE E 503.7.1(4)

**Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Packed Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps - Minimum Efficiency Requirements**

**ASHRAE 90.1: TABLE 6.8.1D-4**

<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</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTAC (cooling mode) Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.5 - (0.213 x Cap/1000)$^3$, EER (before 10/8/2012)</td>
<td>AHRI 310/380</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>13.8 - (0.300 x Cap/1000)$^3$, EER (as of 10/8/2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.0 - (0.300 x Cap/1000)$^3$, (before 1/1/2015)</td>
<td></td>
</tr>
<tr>
<td>PTAC (cooling mode) Nonstandard Size$^2$</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>10.9 - (0.213 x Cap/1000)$^3$, EER</td>
<td></td>
</tr>
<tr>
<td>PTHP (cooling mode) Standard Size</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>12.2 - (0.213 x Cap/1000)$^3$, EER (before 10/8/2012)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14.0 - (0.300 x Cap/1000)$^3$, (as of 1/1/2015)</td>
<td></td>
</tr>
<tr>
<td>PTHP (cooling mode) Nonstandard Size$^2$</td>
<td>All capacities</td>
<td>95°F db outdoor air</td>
<td>10.8 - (0.213 x Cap/1000)$^3$, EER</td>
<td></td>
</tr>
<tr>
<td>PTHP (heating mode) Standard Size</td>
<td>All capacities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.9 - (0.026 x Cap/1000)$^3$ COP$^H$ (before 10/8/2012)</td>
<td></td>
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</tr>
<tr>
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<td></td>
<td></td>
<td>3.2 - (0.026 x Cap/1000)$^3$ COP$^H$ (as of 10/8/2012)</td>
<td></td>
</tr>
<tr>
<td>PTHP (heating mode) Nonstandard Size$^2$</td>
<td>All capacities</td>
<td></td>
<td></td>
<td></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>9.0-10.0 EER</td>
<td>AHRI 390</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and ≤135,000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.8-10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135,000 Btu/h and ≤240,000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.6-10.0 EER</td>
<td></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>9.0-10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and ≤135,000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.8-10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135,000 Btu/h and ≤240,000 Btu/h</td>
<td>95°F db/75°F wb outdoor air</td>
<td>8.6-10.0 EER</td>
<td></td>
</tr>
<tr>
<td>SPVHP (heating mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COP$^H$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and ≤135,000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COP$^H$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135,000 Btu/h and ≤240,000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>2.9-3.0 COP$^H$</td>
<td></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>
</tbody>
</table>
TABLE E 503.7.1(4) (continued)
ELECTRICALLY OPERATED PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL, HEAT PUMPS,
SINGLE-PACKED VERTICAL AIR CONDITIONERS, SINGLE-PACKAGE VERTICAL HEAT PUMPS, ROOM AIR
CONDITIONERS, AND ROOM AIR CONDITIONER HEAT PUMPS - MINIMUM EFFICIENCY REQUIREMENTS

[ASHRAE 90.1: TABLE 6.8.1D-4]

<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>SPVAC (cooling mode), nonweather-ized 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), nonweather-ized 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></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), nonweather-ized space constrained</td>
<td>≤30 000 Btu/h</td>
<td>47°F db/43°F wb outdoor air</td>
<td>3.0 COP H</td>
<td></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 COP H</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner, without louvered sides</td>
<td>&lt;8000 Btu/h</td>
<td>–</td>
<td>9.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥8000 Btu/h and &lt;20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td></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></td>
</tr>
<tr>
<td></td>
<td>≥20 000 Btu/h</td>
<td>–</td>
<td>8.5 EER</td>
<td></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></td>
</tr>
<tr>
<td></td>
<td>≥14 000 Btu/h</td>
<td>–</td>
<td>8.0 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner, casement only</td>
<td>All capacities</td>
<td>–</td>
<td>8.7 EER</td>
<td></td>
</tr>
<tr>
<td>Room air conditioner, casement-slider</td>
<td>All capacities</td>
<td>–</td>
<td>9.5 EER</td>
<td></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 shall be factory labeled as follows: “MANUFACTURED FOR NONSTANDARD SIZE APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION 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” shall mean the rated cooling capacity of the product in Btu/h (kW). Where 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 greater 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)
WARM AIR FURNACES AND COMBINATION WARM AIR FURNACES/AIR-CONDITIONING UNITS,
WARM AIR DUCT FURNACES AND UNIT HEATERS
[ASHRAE 90.1: TABLE 6.8.1E-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 capacity</td>
<td>78% AFUE or 80% $E_t$², ³, ⁴</td>
<td>DOE 10 CFR Part 430 or Section 2.39, Thermal Efficiency, of CSA Z21.47</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td></td>
<td>80% $E_t$³, ⁴</td>
<td>Section 2.39, Thermal Efficiency, of CSA Z21.47</td>
</tr>
<tr>
<td>Warm air furnace, oil-fired</td>
<td>&lt;225 000 Btu/h</td>
<td>Maximum capacity</td>
<td>78% AFUE or 80% $E_t$², ³, ⁴</td>
<td>DOE 10 CFR Part 430 or Section 42, Combustion, of UL 727</td>
</tr>
<tr>
<td></td>
<td>≥225 000 Btu/h</td>
<td></td>
<td>81% $E_t$³</td>
<td>Section 42, Combustion, of UL 727</td>
</tr>
<tr>
<td>Warm air duct furnaces, gas-fired</td>
<td>All capacities</td>
<td>Maximum capacity</td>
<td>80% $E_c$⁵</td>
<td>Section 2.10, Efficiency, of CSA Z83.8</td>
</tr>
<tr>
<td>Warm air unit heaters, gas-fired</td>
<td>All capacities</td>
<td>Maximum capacity</td>
<td>80% $E_c$⁵, ⁶</td>
<td>Section 2.10, Efficiency, of CSA Z83.8</td>
</tr>
<tr>
<td>Warm air unit heaters, oil-fired</td>
<td>All capacities</td>
<td>Maximum capacity</td>
<td>80% $E_c$⁵, ⁶</td>
<td>Section 40, Combustion, of 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 NAECA (three-phase power or cooling capacity greater than or equal to 65 000 Btu/h (19 kW) or more) shall be permitted to comply with either rating.
3. Multiple firing rate units shall be at the maximum firing rate.
4. $E_t$ = thermal efficiency. Units shall 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. $E_c$ = 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 shall also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper. A vent damper is an acceptable alternative to a flue damper for those unit heaters where combustion air is drawn from the conditioned space.
### TABLE E 503.7.1(6)

**GAS AND OIL-FIRED BOILERS, MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1F-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 3/2/2010</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/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired</td>
<td>≥300 000 Btu/h and ≤250 000 Btu/h</td>
<td>70% EF</td>
<td>79% EF</td>
<td>79% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired</td>
<td>&gt;2 500 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Oil-fired</td>
<td>&lt;300 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Oil-fired</td>
<td>≥300 000 Btu/h and ≤250 000 Btu/h</td>
<td>77% EF</td>
<td>77% EF</td>
<td>77% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Oil-fired</td>
<td>&gt;2 500 000 Btu/h</td>
<td>84% EF</td>
<td>84% EF</td>
<td>84% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td>Boilers, steam</td>
<td>Gas-fired</td>
<td>&lt;300 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired – except natural draft</td>
<td>≥300 000 Btu/h and ≤250 000 Btu/h</td>
<td>79% EF</td>
<td>79% EF</td>
<td>79% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired – except natural draft</td>
<td>&gt;2 500 000 Btu/h</td>
<td>84% EF</td>
<td>84% EF</td>
<td>84% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired – natural draft</td>
<td>≥300 000 Btu/h and ≤250 000 Btu/h</td>
<td>77% EF</td>
<td>77% EF</td>
<td>77% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Gas-fired – natural draft</td>
<td>&gt;2 500 000 Btu/h</td>
<td>84% EF</td>
<td>84% EF</td>
<td>84% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Oil-fired</td>
<td>&lt;300 000 Btu/h</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>80% AFUE</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Oil-fired</td>
<td>≥300 000 Btu/h and ≤250 000 Btu/h</td>
<td>81% EF</td>
<td>81% EF</td>
<td>81% EF</td>
<td>10 CFR Part 430</td>
</tr>
<tr>
<td></td>
<td>Oil-fired</td>
<td>&gt;2 500 000 Btu/h</td>
<td>81% EF</td>
<td>81% EF</td>
<td>81% EF</td>
<td>10 CFR Part 430</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 (23443 kW) or less that are not packaged boilers and to all packaged boilers.
2. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.
3. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit’s controls.
4. Includes oil-tired (residual).
5. Date three years after ASHRAE Board Approval.
6. 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.

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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 (23443 kW) or less that are not packaged boilers and to all packaged boilers.
2. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.
3. Maximum capacity – minimum and maximum ratings as provided for and allowed by the unit’s controls.
4. Includes oil-tired (residual).
5. Date three years after ASHRAE Board Approval.
### TABLE E 503.7.1(7)
**PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT**

[ASHRAE 90.1: TABLE 6.8.1G-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&lt;sup&gt;4&lt;/sup&gt;, 5&lt;sup&gt;6&lt;/sup&gt;, 7&lt;sup&gt;5&lt;/sup&gt;</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>≥ 38.2 gpm/hp</td>
<td>CTI ATC-105 and CTI STD-201</td>
</tr>
<tr>
<td></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</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>≥ 14.0 gpm/hp</td>
<td>CTI ATC-105S and CTI STD-201</td>
</tr>
<tr>
<td>Centrifugal fan open-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</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>
</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>
</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>
</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>
</tr>
<tr>
<td>Air-cooled condensers</td>
<td>All</td>
<td>R-22 test fluid 125°F condensing temperature 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>
</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

**Notes:**
1. For purposes of this table, open-circuit cooling tower performance shall be 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 rating.
2. For purposes of this table, closed-circuit cooling tower performance shall be 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 shall be 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.
The efficiencies and test procedures for both open- and closed-circuit cooling towers shall not be applicable to hybrid cooling towers that contain a combination of separate wet and dry heat exchange sections. The certification requirements shall not apply to field-erected cooling towers.

Cooling towers shall comply with the minimum efficiency listed in the table for that specific type of tower with the capacity effect of project-specific accessories, options, or both included in the capacity of the cooling tower.

For purposes of this table, evaporative condenser performance shall be 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.

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 shall be in accordance with the minimum efficiency requirements listed above with R-507A as the test fluid.

### TABLE E 503.7.1(8)
**HEAT TRANSFER EQUIPMENT**

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>SUBCATEGORY</th>
<th>MINIMUM EFFICIENCY&lt;sup&gt;1&lt;/sup&gt;</th>
<th>TEST PROCEDURE&lt;sup&gt;2&lt;/sup&gt;</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 complete specification of the referenced test procedure, including the referenced year version of the test procedure.

### TABLE E 503.7.1(9)
**MINIMUM EFFICIENCY REQUIREMENTS FOR 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>SUB-CATEGORY 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 Multi-split system</td>
<td>13.0 SEER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>11.2 EER 12.3 IEER 12.5 IEER (as of 7/1/2012)</td>
<td>AHRI 1230</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 Multi-split system</td>
<td>11.0 EER 12.3 IEER 12.5 IEER (as of 7/1/2012)</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>10.0 EER 11.1 IEER 11.4 IEER (as of 7/1/2012)</td>
<td>AHRI 1230</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW.
### TABLE E 503.7.1(10)
**MINIMUM EFFICIENCY REQUIREMENTS FOR ELECTRICALLY OPERATED VARIABLE REFRIGERANT-FLOW AIR-TO-AIR 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>SUB-CATEGORY 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 Multi-split system</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>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>11.0 EER</td>
<td>AHRI 1230</td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system with heat recovery</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and ≤240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>10.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h and ≤240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system with heat recovery</td>
<td>10.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>VRF Multi-split system</td>
<td>9.5 EER</td>
<td></td>
</tr>
<tr>
<td>VRF Water source (cooling mode)</td>
<td>&lt;65 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems 86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems with heat recovery 86°F entering water</td>
<td>11.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems 86°F entering water</td>
<td>12.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems 86°F entering water</td>
<td>10.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split systems with heat recovery 86°F entering water</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td>VRF Groundwater source (cooling mode)</td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 59°F entering water</td>
<td>16.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 59°F entering water</td>
<td>16.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 59°F entering water</td>
<td>13.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 59°F entering water</td>
<td>13.6 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 77°F entering water</td>
<td>13.4 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 77°F entering water</td>
<td>13.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system 77°F entering water</td>
<td>11.0 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135 000 Btu/h</td>
<td>All</td>
<td>VRF Multi-split system with heat recovery 77°F entering water</td>
<td>10.8 EER</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 503.7.1(10) (continued)

**MINIMUM EFFICIENCY REQUIREMENTS FOR ELECTRICALLY OPERATED VARIABLE REFRIGERANT-FLOW AIR-TO-AIR AND APPLIED HEAT PUMPS MINIMUM EFFICIENCY REQUIREMENTS**

[ASHRAE 90.1: TABLE 6.8.1J-10]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>NET SENSIBLE COOLING CAPACITY</th>
<th>MINIMUM SCOP-127</th>
<th>EFFICIENCY DOWN-FLOW UNITS/UPFLOW UNITS</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>2.20 / 2.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>1.90 / 1.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled</td>
<td>&lt;65 000 Btu/h</td>
<td>2.60 / 2.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.40 / 2.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioners, water cooled with fluid economizer</td>
<td>&lt;65 000 Btu/h</td>
<td>2.55 / 2.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.35 / 2.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled (rated at 40% propylene glycol)</td>
<td>&lt;65 000 Btu/h</td>
<td>2.50 / 2.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>2.15 / 2.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioners, glycol cooled with fluid economizer (rated at 40% propylene glycol)</td>
<td>&lt;65 000 Btu/h</td>
<td>2.45 / 2.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥65 000 Btu/h and &lt;240 000 Btu/h</td>
<td>2.10 / 1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240 000 Btu/h</td>
<td>2.05 / 1.94</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1. Net sensible cooling capacity: The total gross cooling capacity minus the latent cooling, minus the energy to the air movement system (total gross - latent - fan power).
2. Sensible coefficient of performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheaters and humidifiers) at conditions in accordance with ASHRAE 127. The net sensible cooling capacity shall be the gross sensible capacity minus the energy dissipated into the cooled space by the fan system.

For SI units: 1000 British thermal units per hour = 0.293 kW, °C=(_F-32)/1.8
### TABLE E 503.7.1(12)
#### COMMERCIAL REFRIGERATOR AND FREEZER
#### [ASHRAE 90.1: TABLE 6.8.1-12]

<table>
<thead>
<tr>
<th>EQUIPMENT TYPE</th>
<th>APPLICATION</th>
<th>ENERGY USE LIMITS (kWh/day)</th>
<th>TEST PROCEDURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator with solid doors</td>
<td></td>
<td>$0.10 \times V + 2.04$</td>
<td></td>
</tr>
<tr>
<td>Refrigerator with transparent doors</td>
<td></td>
<td>$0.12 \times V + 3.34$</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>Freezers with solid doors</td>
<td>Holding</td>
<td>$0.40 \times V + 1.38$</td>
<td></td>
</tr>
<tr>
<td>Freezers with transparent doors</td>
<td></td>
<td>$0.75 \times V + 4.10$</td>
<td></td>
</tr>
<tr>
<td>Refrigerators/freezers with solid doors</td>
<td></td>
<td>The greater of $0.12 \times V + 3.34$ or $0.70$</td>
<td></td>
</tr>
<tr>
<td>Commercial refrigerators</td>
<td>Pulldown</td>
<td>$0.126 \times V + 3.51$</td>
<td></td>
</tr>
</tbody>
</table>

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

* $V$ = the chiller or frozen compartment volume (ft³) in accordance with the home appliance manufacturers standard.

### TABLE E 503.7.1(13)
#### COMMERCIAL REFRIGERATION-MINIMUM EFFICIENCY REQUIREMENTS
#### [ASHRAE 90.1: TABLE 6.8.1-13]

<table>
<thead>
<tr>
<th>EQUIPMENT PROCEDURE CLASS</th>
<th>FAMILY CODE</th>
<th>OPERATING MODE</th>
<th>RATING TEMPERATURE</th>
<th>ENERGY USE LIMITS AS OF 1/1/2012² (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>$0.82 \times TDA + 4.07$</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.M</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>$0.83 \times TDA + 3.18$</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.M</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>$0.35 \times TDA + 2.88$</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.L</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>$2.27 \times TDA + 6.85$</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.M</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>$0.57 \times TDA + 6.88$</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.L</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>$0.56 \times TDA + 2.61$</td>
<td></td>
</tr>
<tr>
<td>SOC.RC.M</td>
<td>Service over counter</td>
<td>Remote condensing</td>
<td>Medium temperature</td>
<td>$0.51 \times TDA + 0.11$</td>
<td>AHRI 1200</td>
</tr>
<tr>
<td>VOP.SC.M</td>
<td>Vertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>$1.74 \times TDA + 4.71$</td>
<td></td>
</tr>
<tr>
<td>SVO.SC.M</td>
<td>Semivertical open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>$1.73 \times TDA + 4.59$</td>
<td></td>
</tr>
<tr>
<td>HZO.SC.M</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Medium temperature</td>
<td>$0.77 \times TDA + 5.55$</td>
<td></td>
</tr>
<tr>
<td>HZO.SC.L</td>
<td>Horizontal open</td>
<td>Self contained</td>
<td>Low temperature</td>
<td>$1.92 \times TDA + 7.08$</td>
<td></td>
</tr>
<tr>
<td>VCT.SC.I</td>
<td>Vertical transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>$0.67 \times TDA + 3.29$</td>
<td></td>
</tr>
<tr>
<td>VCS.SC.I</td>
<td>Vertical solid door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>$0.38 \times V + 0.88$</td>
<td></td>
</tr>
<tr>
<td>HCT.SC.I</td>
<td>Horizontal transparent door</td>
<td>Self contained</td>
<td>Ice cream</td>
<td>$0.56 \times TDA + 0.43$</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.L</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Low temperature</td>
<td>$2.27 \times TDA + 6.85$</td>
<td></td>
</tr>
<tr>
<td>VOP.RC.I</td>
<td>Vertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$2.89 \times TDA + 8.7$</td>
<td></td>
</tr>
<tr>
<td>SVO.RC.I</td>
<td>Semivertical open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$2.89 \times TDA + 8.7$</td>
<td></td>
</tr>
<tr>
<td>HZO.RC.I</td>
<td>Horizontal open</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$0.72 \times TDA + 8.74$</td>
<td></td>
</tr>
<tr>
<td>VCT.RC.I</td>
<td>Vertical transparent door</td>
<td>Remote condensing</td>
<td>Ice cream</td>
<td>$0.66 \times TDA + 3.05$</td>
<td></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 (ft³) as measured in accordance with AHRI 1200.

3. $TDA$ is the total display area of the case (ft²) as measured in accordance with AHRI 1200.
### TABLE E 503.7.2(1)
**MINIMUM DUCT INSULATION R-VALUE**<sup>1</sup> FOR COOLING AND HEATING ONLY SUPPLY DUCTS AND RETURN DUCTS

*ASHRAE 90.1: TABLE 6.8.2A-1*

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>DUCT LOCATION</th>
<th>EXTERIOR</th>
<th>VENTILATED ATTIC</th>
<th>UNVENTED ATTIC ABOVE INSULATED CEILING</th>
<th>UNVENTED ATTIC WITH ROOF INSULATION&lt;sup&gt;1&lt;/sup&gt;</th>
<th>UNCONDITIONED SPACE&lt;sup&gt;2&lt;/sup&gt;</th>
<th>INDIRECTLY CONDITIONED SPACE&lt;sup&gt;3&lt;/sup&gt;</th>
<th>BURIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2</td>
<td>HEATING ONLY DUCTS</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>R-6</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
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<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
<td>R-3.5</td>
</tr>
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<td>R-8</td>
<td>R-6</td>
<td>R-3.5</td>
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<td>R-3.5</td>
<td>R-6</td>
</tr>
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<td>COOLING ONLY DUCTS</td>
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<td>R-6</td>
<td>R-8</td>
<td>R-3.5</td>
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<td>R-3.5</td>
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<td>R-6</td>
<td>R-3.5</td>
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<td>R-3.5</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
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<td>R-1.9</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>5, 6</td>
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<td>R-3.5</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>R-1.9</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>7, 8</td>
<td></td>
<td>R-1.9</td>
<td>R-1.9</td>
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<td>R-1.9</td>
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<td>none</td>
<td>none</td>
</tr>
<tr>
<td>1 to 8</td>
<td>RETURN DUCTS</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

**Notes:**

1. Insulation R-values, measured in \([\text{Btu} \cdot \text{in}/(\text{h} \cdot \text{ft}^2 \cdot \degree\text{F})] = [\text{W}/(\text{m} \cdot \text{K})]\), 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 are used as plenum walls, wall insulation shall be in accordance with the most restrictive condition of Section E 503.4.7.2 or ASHRAE 90.1. 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 crawlspaces, both ventilated and nonventilated.

3. Includes return air plenum, with or without exposed roofs above.
# TABLE E 503.7.2(2)
MINIMUM DUCT INSULATION R-VALUE\(^1\) FOR COMBINED HEATING AND COOLING SUPPLY DUCTS AND RETURN DUCTS

[Ashrae 90.1: Table 6.8.2B-2]

<table>
<thead>
<tr>
<th>CLIMATE ZONE</th>
<th>EXTERIOR</th>
<th>VENTILATED ATTIC</th>
<th>UNVENTED ATTIC ABOVE INSULATED CEILING</th>
<th>UNVENTED ATTIC WITH ROOF INSULATION(^1)</th>
<th>UNCONDITIONED SPACE(^2)</th>
<th>INDIRECTLY CONDITIONED SPACE(^3)</th>
<th>BURIED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SUPPLY DUCTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>R-6</td>
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<td>R-8</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>2</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>3</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>R-3.5</td>
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<td>R-3.5</td>
</tr>
<tr>
<td>4</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>5</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>6</td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>7</td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>8</td>
<td>R-8</td>
<td>R-8</td>
<td>R-8</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td></td>
<td>RETURN DUCTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 8</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

Notes:
1. Insulation R-values, measured in \([\text{Btu} \cdot \text{in} / (\text{h} \cdot \text{ft}^2 \cdot \degree\text{F})] = \text{W}/(\text{m} \cdot \text{K})\), 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 are used as plenum walls, wall insulation shall be in accordance with the most restrictive condition of Section E.503.4.7.2 or ASHRAE 90.1. 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 crawlspaces, both ventilated and nonventilated.
3. Includes return air plenum, with or without exposed roofs above.
TABLE E 603.7.2(3) 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 6.8.3A-1]

<table>
<thead>
<tr>
<th>FLUID DESIGN 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 - 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:
\[
T = r \left( \frac{1 + t/r}{K/k} - 1 \right)
\]
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/in/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 required relative to safety issues/surface temperature.
3 For piping 1½ inches (40 mm) or less and located in partitions within conditioned spaces, reduction of insulation thickness by 1 inch (25.4 mm) shall be permitted before thickness adjustment required in footnote 1, but not a thickness less than 1 inch (25.4 mm).
4 For direct-buried heating and hot water system piping, reduction of insulation thickness by 1½ inch (40 mm) shall be permitted before thickness adjustment required in footnote 1, but not a thickness less than 1 inch (25.4 mm).
5 Table E 603.7.3(1) 503.7.3(1) is based on steel pipe. Non-metallic pipes, less than schedule 80 thickness 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 permitted where documentation is provided showing that the pipe with the proposed insulation has less heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 603.7.2(3) 503.7.3(1).
### APPENDIX E

**TABLE E 503.7.2(4) 503.7.3(2)**  
**MINIMUM PIPE INSULATION THICKNESS FOR COOLING SYSTEMS (CHILLED WATER, BRINE, AND REFRIGERANT)**$^{1,2,3,4}$  
[ASHRAE 90.1: TABLE 6.8.3B-2]

<table>
<thead>
<tr>
<th>FLUID OPERATING TEMPERATURE RANGE (°F) AND USAGE</th>
<th>CONDUCTIVITY Btu•inch/(h•ft²•°F) t</th>
<th>MEAN RATING TEMPERATURE °F</th>
<th>NOMINAL PIPE SIZE OR TUBE SIZE (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td>40°F - 60°F</td>
<td>021 - 0.27</td>
<td>75</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 to &lt;1-1/2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1-1/2 to &lt;4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 to &lt;8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>&lt;40°F</td>
<td>0.20 - 0.26</td>
<td>50</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**INSULATION THICKNESS (inches)**

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:
   
   $T = r \left( 1 + \frac{t}{r} \right) K/k - 1$

   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•inch/(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. 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.

4. Table E 503.7.2(4) 503.7.3(2) is based on steel pipe. Non-metallic pipes less than schedule 80 thickness 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 heat transfer per foot (mm) than a steel pipe of the same size with the insulation thickness shown in Table E 503.7.3(4) 503.7.3(2).
E 503.8.2 The computer room $PUE_0$ shall be not more than the values listed in Table E 503.8.1. The $PUE_0$ shall be the highest value determined at outdoor cooling design temperatures, and shall be limited to systems utilizing electricity for an energy source. $PUE_0$ shall be calculated for the following 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 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 Code.

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

E 505.5 Piping and Tubing Materials Standards. Ground source heat pump ground-loop pipe and tubing shall comply with the standards listed in Table E 505.5.

### TABLE E 505.5

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F411; ASTM F441; ASTM F442</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F876; ASTM F877; CSA B137.5</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-R)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC)</td>
<td>ASTM D1785; ASTM D2241</td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM F2623; ASTM F2769</td>
</tr>
</tbody>
</table>

E 505.6 Fittings. 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.

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 506.6 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 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, ½ 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 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 507.0 Valves.
E 507.1 Where Required. Shutoff valves shall be installed in ground source-loop piping systems in the locations indicated in Section E 507.2 through Section E 507.8.

E 507.2 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 Central Systems. Shutoff valves shall be installed on the building supply and return of a central utility system.

E 507.4 Pressure Vessels. Shutoff valves shall be installed on the connection to a pressure vessel.

E 507.5 Pressure-Reducing Valves. Shutoff valves shall be installed on both sides of a pressure-reducing valve.

E 507.6 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 Expansion Tanks. Shutoff valves shall be installed at connections to nondiaphragm-type expansion tanks.

E 507.8 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 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 508.5 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 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 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 Pipe Support. Pipe shall be supported in accordance with Section 314.1.

E 508.9 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 508.10 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 508.11 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 Transfer Fluid. The transfer fluid shall be compatible with the makeup water supplied to the system.

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 509.2 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.

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 602.1 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 through Section E 602.1.3.

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 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 and, or, equivalently, 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 Whole-Building Ventilation. A mechanical exhaust system, supply system, or combination thereof shall be installed to operate for each dwelling unit to provide continuous whole-building ventilation with outdoor air rate each hour at not less than the rate specified in Section E 605.1.3.1, Table E 605.1.2 or, equivalently, Equation E 605.1.3(1) and Equation E 605.1.3(2), based on the floor area of the conditioned space and number of bedrooms.

Exception. An intermittently operating whole-building mechanical ventilation system shall be permitted where the ventilation rate is in accordance with Section E 605.1.7. The system shall be designed for automatic operation. [ASHRAE 62.2:4.1.1]

E 605.1.3.1 Total Ventilation Rate. The total required ventilation rate \( Q_{\text{tot}} \) shall be as specified in Table E 605.1.3.1 or, alternatively, calculated in accordance with Equation E 605.1.3.1.

\[
Q_{\text{tot}} = 0.040 \times 0.034 + 7.5(N_{br} + 1) 
\]

Where:
\[
Q_{\text{fan}} = \text{fan flow rate, ft}^3/\text{min} \]
\[
A_{\text{floor}} = \text{floor area of residence, square feet (ft}^2) \]
\[
N_{br} = \text{number of bedrooms; not to be less than one} \]

E 605.1.3.2 Alternative Ventilation. Other methods shall be permitted to be used to provide the required ventilation rates (in accordance with Table E 605.1.3.1) where approved by a licensed design professional. [ASHRAE 62.2:4.1.2]

E 605.1.3.3 Infiltration Credit. Section E 605.1.3 includes a default credit for ventilation provided by infiltration of 2 ft³/min per 100 square feet [0.0001 m³/s/m²] of occupiable floor space. For buildings built prior to the application of this appendix, where excess infiltration has been measured using ASHRAE 136, the rates in Section E 605.1.3 shall be permitted to be decreased by half of the excess of the rate calculated from ASHRAE 136 that is above the default rate. [ASHRAE 62.2:4.1.3]

E 605.1.4 System Type. The whole-house 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 whole-building ventilation, the local exhaust airflow shall be permitted to be
TABLE E 605.1.3.1
VENTILATION AIR REQUIREMENTS, (cubic foot per minute)
[ASHRAE 62.2: TABLE 4.1a]

<table>
<thead>
<tr>
<th>FLOOR AREA (ft²)</th>
<th>0-1</th>
<th>2-3</th>
<th>4-5</th>
<th>6-7</th>
<th>8+</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤500</td>
<td>30</td>
<td>38</td>
<td>45</td>
<td>53</td>
<td>60</td>
</tr>
<tr>
<td>501-1000</td>
<td>45</td>
<td>53</td>
<td>60</td>
<td>68</td>
<td>75</td>
</tr>
<tr>
<td>1001-1500</td>
<td>60</td>
<td>68</td>
<td>75</td>
<td>82</td>
<td>90</td>
</tr>
<tr>
<td>1501-2000</td>
<td>75</td>
<td>83</td>
<td>90</td>
<td>98</td>
<td>105</td>
</tr>
<tr>
<td>2001-2500</td>
<td>90</td>
<td>98</td>
<td>105</td>
<td>113</td>
<td>120</td>
</tr>
<tr>
<td>2501-3000</td>
<td>105</td>
<td>113</td>
<td>120</td>
<td>128</td>
<td>135</td>
</tr>
<tr>
<td>3001-3500</td>
<td>120</td>
<td>128</td>
<td>135</td>
<td>143</td>
<td>150</td>
</tr>
<tr>
<td>3501-4000</td>
<td>135</td>
<td>143</td>
<td>150</td>
<td>158</td>
<td>165</td>
</tr>
<tr>
<td>4001-4500</td>
<td>150</td>
<td>158</td>
<td>165</td>
<td>173</td>
<td>180</td>
</tr>
<tr>
<td>4501-5000</td>
<td>165</td>
<td>173</td>
<td>180</td>
<td>188</td>
<td>195</td>
</tr>
</tbody>
</table>

For SI units: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.00047 m³/s

Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.

credited towards the whole-building 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 using a flow hood, flow grid, or other airflow measuring device. 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. The “fan on” switch on a heating or air-conditioning system shall be permitted as an operational control for systems introducing ventilation air through a duct to the return side of an HVAC system. Readily accessible override control shall be provided to the occupant. Local exhaust fan switches and “fan-on” switches shall be permitted as override controls. Controls, including the “fan-on” switch of a conditioning system, shall be appropriately labeled.

Exception: An intermittently operating whole-house mechanical ventilation system shall be permitted to be used where the ventilation rate is adjusted according to the exception to Section E 605.1.7. The system shall be designed so that it operates automatically based on a timer. The intermittent mechanical ventilation system shall operate not less than once per day and must operate not less than 10 percent of the time. [ASHRAE 62.2:4.4]

E 605.1.7 Delivered Ventilation. The delivered ventilation rate shall be calculated as the larger of total supply or total exhaust and shall be no less than specified in Section E 605.1.3 during each hour of operation.

Exception: The effective ventilation rate of an intermittent system is the combination of its delivered capacity, fractional on-time, cycle time, and the ventilation effectiveness from Table E 605.1.7. The fan flow rate required to achieve an effective ventilation rate that is equivalent to the continuous ventilation requirement shall be calculated from the following equation [ASHRAE 62.2:4.5]:

E 605.1.7.1 Intermittent Ventilation. Whole-building mechanical systems designed to provide intermittent ventilation shall be in accordance with Section E 605.1.7.1 and Section E 605.1.7.2. [ASHRAE 62.2:4.5]

E 605.1.7.2 Extended-Cycle Intermittent Ventilation. Where mechanical ventilation is not provided at least once every three hours by a single fan system, the intermittent fan airflow rate Q_on

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#### TABLE E 605.1.7.2 605.1.7.2

**MECHANICAL VENTILATION EFFECTIVENESS (μ) FOR INTERMITTENT FANS**

[ASHRAE 62.2: TABLE 4.2]

<table>
<thead>
<tr>
<th>FRACTIONAL ON-TIME, f</th>
<th>CYCLE-TIME T_cyc (hours)</th>
<th>0.00</th>
<th>0.10</th>
<th>0.20</th>
<th>0.30</th>
<th>0.40</th>
<th>0.50</th>
<th>0.60</th>
<th>0.70</th>
<th>0.80</th>
<th>0.90</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>1.00</td>
<td>0.42</td>
<td>0.46</td>
<td>0.76</td>
<td>0.82</td>
<td>0.88</td>
<td>0.92</td>
<td>0.96</td>
<td>0.98</td>
<td>1.00</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>0.2</td>
<td>1.00</td>
<td>0.40</td>
<td>0.46</td>
<td>0.76</td>
<td>0.82</td>
<td>0.88</td>
<td>0.92</td>
<td>0.96</td>
<td>0.98</td>
<td>1.00</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>0.3</td>
<td>1.00</td>
<td>0.38</td>
<td>0.44</td>
<td>0.74</td>
<td>0.80</td>
<td>0.86</td>
<td>0.90</td>
<td>0.94</td>
<td>0.96</td>
<td>1.00</td>
<td>0.99</td>
<td>1.00</td>
</tr>
<tr>
<td>0.4</td>
<td>1.00</td>
<td>0.36</td>
<td>0.42</td>
<td>0.72</td>
<td>0.78</td>
<td>0.84</td>
<td>0.88</td>
<td>0.92</td>
<td>0.94</td>
<td>0.96</td>
<td>0.95</td>
<td>1.00</td>
</tr>
<tr>
<td>0.5</td>
<td>1.00</td>
<td>0.34</td>
<td>0.40</td>
<td>0.70</td>
<td>0.76</td>
<td>0.82</td>
<td>0.86</td>
<td>0.90</td>
<td>0.92</td>
<td>0.94</td>
<td>0.93</td>
<td>1.00</td>
</tr>
<tr>
<td>0.6</td>
<td>1.00</td>
<td>0.32</td>
<td>0.38</td>
<td>0.68</td>
<td>0.74</td>
<td>0.80</td>
<td>0.84</td>
<td>0.88</td>
<td>0.90</td>
<td>0.92</td>
<td>0.91</td>
<td>1.00</td>
</tr>
<tr>
<td>0.7</td>
<td>1.00</td>
<td>0.30</td>
<td>0.36</td>
<td>0.66</td>
<td>0.72</td>
<td>0.78</td>
<td>0.82</td>
<td>0.86</td>
<td>0.88</td>
<td>0.90</td>
<td>0.89</td>
<td>1.00</td>
</tr>
<tr>
<td>0.8</td>
<td>1.00</td>
<td>0.28</td>
<td>0.34</td>
<td>0.64</td>
<td>0.70</td>
<td>0.76</td>
<td>0.80</td>
<td>0.84</td>
<td>0.86</td>
<td>0.88</td>
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</tr>
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<td>1.00</td>
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<td>0.32</td>
<td>0.62</td>
<td>0.68</td>
<td>0.74</td>
<td>0.78</td>
<td>0.82</td>
<td>0.84</td>
<td>0.86</td>
<td>0.85</td>
<td>1.00</td>
</tr>
<tr>
<td>1.0</td>
<td>1.00</td>
<td>0.24</td>
<td>0.30</td>
<td>0.60</td>
<td>0.66</td>
<td>0.72</td>
<td>0.76</td>
<td>0.80</td>
<td>0.82</td>
<td>0.84</td>
<td>0.83</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Notes:

1. Condition not allowed since no amount of intermittent ventilation will provide equivalent indoor air quality.
2. Interpolation in Table E 605.1.7 is not allowed. For values not listed, use the next higher value for Cycle Time or the next lower value for Fractional On-Time. The maximum allowed Cycle Time is 24 hours and the minimum allowed Fractional On-Time is 0.1.

### Notes

- **fan cycle time, defined as the total time for 1 on-cycle and 1 off-cycle (used in Table E 605.1.7)**
- **f** = mechanical ventilation effectiveness (from Table E 605.1.7.2)
- **fractional on-time, defined as the on-time for one cycle divided by the cycle time.**

Table E 605.1.7.2 also requires the calculation of the required turnover, N, in accordance with the following:

\[ N = \frac{\epsilon}{Q_{\text{fan}} T_cyc A_{\text{floor}}} \]  

Where:

\( Q_f \) = intermittent fan airflow rate during the on-cycle

\( Q_{\text{fan}} \) = continuous mechanical ventilation airflow rate (from Table E 605.1.3.1 or Equation E 605.1.3.1)

\( \epsilon \) = mechanical ventilation effectiveness (from Table E 605.1.7.2)

\( T_cyc \) = fan cycle time, defined as the total time for 1 on-cycle and 1 off-cycle (used in Table E 605.1.7)

\( A_{\text{floor}} \) = floor area

\( Q_{\text{fan}} \times T_cyc \times A_{\text{floor}} \) = fan airflow rate during the on-cycle
See ASHRAE 24 for an example of this calculation. For values not listed in Table 605.1.7.2, use the next higher value for \( N \) or the next lower value for \( \tau_c \). Linear interpolation shall be permitted for intermediate fractional values. The maximum allowed cycle time shall be 24 hours and the minimum allowed fractional on-time shall be 0.1. [ASHRAE 62.2:4.5.2]

E 605.1.8 Equivalent Ventilation. A whole-building 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 605.1.8.1 Hot, Humid Climates. In hot, humid climates, whole house mechanical net exhaust flow shall not exceed 7.5 ft³/min per 100 square feet [0.0004 \( \text{m}^3/\text{s} \)/m²]. (See ASHRAE 62.2 for a listing of hot, humid US climates) [ASHRAE 62.2:4.6.1]

E 605.1.8.2 Very Cold Climates. Mechanical supply systems exceeding 7.5 ft³/min per 100 square feet [0.0004 \( \text{m}^3/\text{s} \)/m²] shall not be used in very cold climates. (See ASHRAE 62.2 for a listing of very cold US climates)

Exception: These ventilation strategies are not restricted where the Authority Having Jurisdiction approves the envelope design as being moisture resistant. [ASHRAE 62.2:4.6.2]

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 and Section E 608.12.

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, 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.
5. Functional performance.
7. Post construction documentation and training.
8. Commissioning report.

HVAC systems and components covered by this appendix as well as process equipment and controls, and renewable energy systems shall be included in the scope of the commissioning requirements.

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.
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.
APPENDIX E

(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) Review of the certification requirements.

(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 technician shall sign the certificate of acceptance to certify that the information he provides on the certificate of acceptance is true and correct.

E 803.2.1.2 Responsible Person. The responsible person shall be the contractor or registered design professional of record. A certificate of acceptance shall be signed by a responsible person to take responsibility for the scope of work specified by the certificate of acceptance document. The responsible person shall perform the field testing and verification work, and where this is the case, the responsible person shall complete and sign both the field technician’s signature block and the responsible person’s signature block on the certificate of acceptance form. The responsible person assumes responsibility for the acceptance testing work performed by the field technician agent or employee.

E 803.2.1.3 Certificate of Acceptance. The certificate of acceptance shall be submitted to the Authority Having Jurisdiction in order to receive the final certificate of occupancy. The Authority Having Jurisdiction shall not release a final certificate of occupancy unless the submitted certificate of acceptance demonstrates that the specified systems and equipment have been shown to be performing in accordance with the applicable acceptance requirements. The Authority Having Jurisdiction has the authority to require the field technician and responsible person to demonstrate competence, to its satisfaction. Certificate of acceptance forms are located in Section E 806.0.

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).

(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 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 air 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 or 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 or 30 percent of the total design airflow. Verify and document the following:

(1) Measured outside 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 outside 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 air volume 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 outside 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:

1. Thermostat is located within the space-conditioning zone that is served by the HVAC system.
2. Thermostat shall be in accordance with temperature adjustment and dead band requirements.
3. Occupied, unoccupied, and holiday schedules shall be programmed per the facility’s schedule.
4. 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. The unit provides cooling.
3. No heating is provided by the unit.
4. 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. Supply fan is off.
3. Outside air damper is fully closed.
4. Neither heating nor cooling is provided by the unit.

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 at minimum position.
3. Outside air damper is either closed or at minimum position.

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. System is in “occupied” mode.
2. System reverts to “unoccupied” mode where manual override time period expires.
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.

For units with economizers that are factory installed and certified operational by the manufacturer to economizer quality control requirements, the in-field economizer functional tests do not have to be conducted. A copy of the manufacturer’s certificate shall be attached to the Form MECH-5A. However, the construction inspection, including compliance with high temperature lockout temperature setpoint, shall be completed regardless of whether the economizer is field or factory installed.

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 shall 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.

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 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 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: Open control valves to increase water flow to not less than 90 percent design flow. 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.
3. System operation shall stabilize within 5 minutes after test procedures are initiated.

Step 2: Modulate control valves to reduce water flow to 50 percent of the design flow or less, but not lower than the pump minimum flow. Verify and document the following:

1. Pump speed decrease.
2. Current operating setpoint has decreased (for systems with DDC to the zone level).
3. Current operating setpoint has not increased (for all other systems).
4. System pressure is within 5 percent of current operating setpoint.
5. System operation stabilizes within 5 minutes after test procedures are initiated.

**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 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.
2. 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 deadband to not more than 2°F (-1°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 lockout 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 805.12.1.2 Functional Testing. The functional testing shall be in accordance with the following steps:
Step 1: Test low airflow condition by replacing the existing filter with a dirty filter or appropriate obstruction.
Step 2: Verify that the fault detection and diagnostics system reports the fault.
Step 3: Verify that the system is able to verify the correct refrigerant charge.
Step 4: Calibrate outside air, return air, and supply air temperature sensors.

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 compliance 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(A) and Section E 805.13.1.1(B).

E 805.13.1.1(A) 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.
(5) From the control system workstation, command the mixing box dampers to a full-closed position (0 percent outdoor air).
(6) Disconnect power to the actuator and verify that a fault is reported at the control workstation.
(7) Reconnect power to the actuator and command the dampers closed.
(8) 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.
(2) Reconnect power to the actuator and command the mixing box dampers to full open.
(3) Verify that the control system does not report a fault.
(4) From the control system workstation, command the mixing box dampers to full closed (0 percent outdoor air).
(5) Disconnect power to the actuator and verify that a fault is reported at the control workstation.
(6) Reconnect power to the actuator and command the dampers closed.
(7) Verify that the control system does not report a fault during normal operation.
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.
(2) From the control system workstation, over-
ride the cooling coil valve and verify that a
fault is reported at the control workstation.

(3) From the control system workstation, over-
ride the mixing box dampers and verify
that a fault is reported at the control work-
station.

E 805.13.1.1(B) 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 posi-
tion.
(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 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.

Step 4: Simulate a cooling load during morning shoulder time period. Verify and document the following:

1. 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).
   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. 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 indoor air temperature setpoint below the ambient temperature. Verify that the tank starts discharging and the compressor is off.

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

Page 1 of 3

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).
• 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).
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Company Name:

Responsible Person’s Name: Responsible Person’s Signature:

License: Date Signed: Position With Company (Title):
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| Date Signed: | Position with Company (Title): |

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CERTIFICATE OF ACCEPTANCE

Outdoor Air Acceptance

Intent: Verify measured outside airflow reading is within ± 10% of the total required outside airflow value found in Section E 501.0 through Section E 505.1.2

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)
   CAV    VAV
   a. Verify unit is not in economizer mode during test - check appropriate column.

Step 1: CAV and VAV testing at full supply airflow.
   a. Adjust supply to achieve design airflow.
   b. Measured outdoor airflow reading (ft³/min).
   c. Required outdoor airflow (ft³/min).
   d. Time for outside air damper to stabilize after VAV boxes open (minutes).
   e. Return to initial conditions (check).

Step 2: VAV testing at reduced supply airflow.
   a. Adjust supply airflow to either the sum of the minimum zone airflows or 30% of the total design airflow.
   b. Measured outdoor airflow reading (ft³/min).
   c. Required outdoor airflow (ft³/min).
   d. Time for outside air damper to stabilize after VAV boxes open and minimum airflow achieved (minutes).
   e. Return to initial conditions (check).

B. Testing Calculations and Results.
   CAV    VAV
   Percent OSA at full supply airflow (%OAFA for Step 1).
   a. \(\%OA_{FA} = \frac{\text{Measured outside air reading}}{\text{Required outside air (Step 1b / Step 1c)}}\)
      \%      \%
   b. \(90\% \leq \%OA_{FA} \leq 110\%\)
      Y / N   Y / N
   c. Outside air damper position stabilizes within 15 minutes (Step 1d < 15 minutes)
      Y / N   Y / N
  
   Percent OSA at reduced supply airflow (%OA_RA for Step 2).
   a. \(\%OA_{RA} = \frac{\text{Measured outside air reading/required outside air (Step 2b / Step 2c)}}{\text{Required outside airflow (ft³/min)}}\)
      \%      \%
   b. \(90\% \leq \%OA_{RA} \leq 110\%\)
      Y / N   Y / N
   c. Outside air damper position stabilizes within 15 minutes (Step 2d < 15 minutes)
      Y / N   Y / N

Note: Shaded boxes do not apply for CAV systems.

For SI units: 1 cubic foot per minute = 0.00047 m³/s
### 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.
**CERTIFICATE OF ACCEPTANCE**

### Constant Volume Single Zone Unitary Air Conditioner and Heat Pump Systems

<table>
<thead>
<tr>
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CERTIFICATE OF ACCEPTANCE
MECH-3A

Constant Volume Single Zone Unitary Air Conditioner and Heat Pump Systems

Project Name/Address: 
System Name or Identification/Tag: 
System Location or Area Served: 

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):
   □ Thermostat meets the temperature adjustment and dead band requirements.
   □ Occupied, unoccupied, and holiday schedules have been programmed per the facility’s schedule.
   □ Preoccupation purge has been programmed to meet the requirements of Section E 501.0 through Section E 505.1.42.

A. Functional Testing Requirements.

<table>
<thead>
<tr>
<th>Operating Modes</th>
<th>Cooling load during occupied condition</th>
<th>Manual override</th>
<th>No-load during occupied condition</th>
<th>Heating load during occupied condition</th>
<th>No-load during unoccupied condition</th>
<th>Heating load during unoccupied condition</th>
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Step 1: Check and verify the following for each simulation mode required.

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B. Testing Results

Indicate if Passed (P), Failed (F), or N/A (X), fill in appropriate letter.
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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.

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**PRE-PRINT**

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**UNIFORM MECHANICAL CODE**
### CERTIFICATE OF ACCEPTANCE

**Air Distribution Systems Acceptance**

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</table>

<table>
<thead>
<tr>
<th>License:</th>
<th>Date Signed:</th>
<th>Position With Company (Title):</th>
</tr>
</thead>
</table>
### 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:**
   - a. 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 501.0 through Section E 505.1.42.
   - 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 501.0 through Section E 505.1.42.

For SI units: 1 square foot = 0.0929 m²
Air Distribution System Leakage Diagnostic.

The installing contractor must pressure test every new HVAC systems that meet the requirements of Section E 501.0 through Section E 505.1.42 and every retrofit to existing HVAC systems that meet the requirements of Section E 501.0 through Section E 505.1.42.

RATED FAN FLOW (applies to all systems)

1. Cooling capacity or for heating only units heating capacity.
   (a) Cooling capacity (for all units but heating only units) in tons.
   (b) Heating capacity (for heating only units) kBtu/h.

2. Fan flow calculation
   (a) Cooling capacity in tons \[ \frac{\text{Line #1a}}{400 \text{ ft}^3/\text{min/ton}} \]
   (b) Heating only cap. kBtu/h \[ \frac{\text{Line #1b}}{21.7 \text{ ft}^3/\text{min/kBtu/h}} \]

3. Total calculated supply fan flow \(2(a)\) or \(2(b)\) ft\(^3\)/min.

NEW CONSTRUCTION OR ENTIRE NEW DUCT SYSTEM ALTERATION:

Duct pressurization test results (ft\(^3\)/min @ 25 Pa).

4. Enter tested leakage flow in ft\(^3\)/min:

5. Pass if leakage percentage \(\leq 6\%\): \(\frac{\text{Line #4}}{\text{Line #3}} \times 100\) %

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 <15% \(\frac{\text{Line #7}}{\text{Line #3}} \times 100\) %

9. Pass if leakage reduction percentage >60% \(\text{Leakage reduction} = [1 - \frac{\text{Line #7}}{\text{Line #6}}] \times 100\) %

10. Pass if all accessible leaks are sealed as confirmed by visual inspection and verification by HERS rater (sampling rate 100%).

\(\text{Pass if One of Lines #8 through #10 pass}\)

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 cubic foot per minute = 0.00047 m\(^3\)/s, 1 metric ton = 1000 kg
## CERTIFICATE OF ACCEPTANCE

**Air Economizer Controls 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).
- 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.
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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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#### Company Name:

#### Responsible Person’s Name:

#### Responsible Person’s Signature:

#### License:

#### Date Signed:

#### Position With Company (Title):
### Construction Inspection

1. **Instrumentation to perform test includes, but not limited to:**
   - Handheld temperature probes calibration. 
     - Date: (must be within last year).
   - 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 501.0 through Section E 505.1.4.**
   - **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.

**PASS / FAIL**

**Step 1:** Simulate cooling load and enable the economizer (all check boxes are complete).

**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).
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

**MECH-6A**

**Demand Control Ventilation Systems Acceptance**

**Project Name/Address:**

<table>
<thead>
<tr>
<th>System Name or Identification/Tag:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Enforcement Agency:</th>
<th>Permit Number:</th>
</tr>
</thead>
</table>

**Note:** Submit one Certificate of Acceptance for each system that must demonstrate compliance.

## FIELD TECHNICIAN’S DECLARATION STATEMENT

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## RESPONSIBLE PERSON’S DECLARATION STATEMENT

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 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>
</tbody>
</table>
| b. Outside air CO₂ concentration (select one of the following).
   - Measured dynamically using CO₂ sensor. |
   - Interior CO₂ concentration setpoint (Outside CO₂ concentration + 600 ppm). |

#### 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 modulate 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 modulate 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.

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
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</table>

## CERTIFICATE OF ACCEPTANCE

**MECH-6A**

**Demand Control Ventilation Systems Acceptance**

(Please fill out necessary information)
CERTIFICATE OF ACCEPTANCE

Supply Fan VFD Acceptance

MECH-7A

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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Company Name:

Field Technician’s Name:

Field Technician’s Signature:

Date Signed: Position with Company (Title):

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Company Name:

Responsible Person’s Name:

Responsible Person’s Signature:

License: Date Signed: Position With Company (Title):
CERTIFICATE OF ACCEPTANCE

Supply Fan VFD Acceptance

Project Name/Address:  

System Name or Identification/Tag:  
System Location or Area Served:  

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:
   a. Calibrated differential pressure gauge.

2. Installation.
   a. Discharge static pressure sensors are either factory calibrated or field-calibrated.
   b. The static pressure location, setpoint, and reset control meets the requirements of Section E 501.0 through Section E 505.1.4.

3. Documentation of all discharge static pressure sensors including (check one of the following):
   a. Field-calibrated.
   b. Calibration complete, all pressure sensors within 10% of calibrated reference sensor.

**A. Functional Testing.**

<table>
<thead>
<tr>
<th>Step 1: Drive all VAV boxes to achieve design airflow.</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Supply fan controls modulate to increase capacity.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b. Supply fan maintains discharge static pressure within +/-10% of the current operating setpoint.</td>
<td>Y / N</td>
</tr>
<tr>
<td>c. Supply fan controls stabilize within a 5 minute period.</td>
<td>Y / N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2: Drive all VAV boxes to minimum flow.</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Supply fan controls modulate to decrease capacity.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b. Current operating setpoint has decreased (for systems with DDC to the zone level).</td>
<td>Y / N</td>
</tr>
<tr>
<td>c. Supply fan maintains discharge static pressure within +/-10% of the current operating setpoint.</td>
<td>Y / N</td>
</tr>
<tr>
<td>d. Supply fan controls stabilize within a 5 minute period.</td>
<td>Y / N</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3: System returned to initial operating conditions.</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y / N</td>
</tr>
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</table>

**B. Testing Results.**

<table>
<thead>
<tr>
<th>Step 1: Drive all VAV boxes to achieve design airflow.</th>
<th>PASS / FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Drive all VAV boxes to minimum flow.</td>
<td></td>
</tr>
</tbody>
</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.
**CERTIFICATE OF ACCEPTANCE**

**Valve Leakage Test**  

**MECH-8A**  

**APPENDIX E**  

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
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<tr>
<td>License:</td>
<td>Date Signed:</td>
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</tbody>
</table>
### A. Functional Testing

#### Pump Tag (Id)

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

#### Step 1: Determine pump dead head pressure.

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet Water Column</td>
</tr>
<tr>
<td>Feet Water Column</td>
</tr>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

#### Step 2: Automatically close all valves on the systems being tested. If three-way valves are present, close off the bypass line(s).

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet Water Column</td>
</tr>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

#### 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: Pressure measurement is within 5% of submittal data for all pumps.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</table>

#### Step 2: Pressure measurements are within 5%.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
</tr>
</tbody>
</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.

For SI units: 1 inch water column = 0.249 kPa
CERTIFICATE OF ACCEPTANCE

Supply Water Temperature Reset Controls Acceptance

(PAGE 1 OF 2)

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: 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.
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Company Name:

Responsible Person’s Name: Responsible Person’s Signature:

License: Date Signed: Position With Company (Title):
### 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.**

<table>
<thead>
<tr>
<th>Action</th>
<th>Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Change reset control variable to its maximum value.</td>
<td></td>
</tr>
<tr>
<td>b. Verify that chilled or hot water temperature setpoint is reset to appropriate value.</td>
<td></td>
</tr>
<tr>
<td>c. Verify that actual system temperature changes to within 2% of the new setpoint.</td>
<td></td>
</tr>
</tbody>
</table>

**Step 2: Test minimum reset value.**

<table>
<thead>
<tr>
<th>Action</th>
<th>Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Change reset control variable to its minimum value.</td>
<td></td>
</tr>
<tr>
<td>b. Verify that chilled or hot water temperature setpoint is reset to appropriate value.</td>
<td></td>
</tr>
<tr>
<td>c. Verify that actual system temperature changes to within 2% of the new setpoint.</td>
<td></td>
</tr>
</tbody>
</table>

**Step 3: Test maximum reset value.**

<table>
<thead>
<tr>
<th>Action</th>
<th>Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Restore reset control variable to automatic control.</td>
<td></td>
</tr>
<tr>
<td>b. Verify that chilled or hot water temperature setpoint is reset to appropriate value.</td>
<td></td>
</tr>
<tr>
<td>c. Verify that actual supply temperature changes to meet setpoint.</td>
<td></td>
</tr>
<tr>
<td>d. Verify that actual supply temperature changes to within 2% of the new setpoint.</td>
<td></td>
</tr>
</tbody>
</table>

### B. Testing Results.

System passes criteria in 1c, 2c, and 3d.

<table>
<thead>
<tr>
<th>PASS / FAIL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System passes criteria in 1c, 2c, and 3d.</td>
<td></td>
</tr>
</tbody>
</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. |
**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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## CERTIFICATE OF ACCEPTANCE

**MECH-10A**

**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:
   - 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 501.0 through Section E 505.1.4.

3. Documentation of all control pressure sensors including (check one of the following):
   - Factory-calibrated (proof required).
     - Factory-calibration certificate.
   - Field-calibrated.
     - Calibration complete, all pressure sensors within 10% of calibrated reference sensor.

### A. Functional Testing

#### Step 1: Design flow test.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Open control valves to achieve a minimum of 90% of design flow.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b.</td>
<td>Verify that the pump speed increases.</td>
<td>Y / N</td>
</tr>
<tr>
<td>c.</td>
<td>Are the pumps operating at 100% speed?</td>
<td>Y / N</td>
</tr>
<tr>
<td>d.</td>
<td>Record the system pressure as measured at the control sensor. (Feet Water Column) =</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Record the system pressure setpoint. (Feet Water Column) =</td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Is the pressure reading in d within 5% of pressure setpoint in e?</td>
<td>Y / N</td>
</tr>
<tr>
<td>g.</td>
<td>Did the system operation stabilize within 5 minutes after completion of step 1a?</td>
<td>Y / N</td>
</tr>
</tbody>
</table>

#### Step 2: Low flow test

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Close coil control valves to achieve a maximum of 50% of design flow.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b.</td>
<td>Verify that the current operating speed decreases (for systems with DDC to the zone level).</td>
<td>Y / N</td>
</tr>
<tr>
<td>c.</td>
<td>Verify that the current operating speed has not increased (for all other systems that are not DDC).</td>
<td>Y / N</td>
</tr>
<tr>
<td>d.</td>
<td>Record the system pressure as measured at the control sensor. (Feet Water Column) =</td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Record the system pressure setpoint. (Feet Water Column) =</td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Is the setpoint in e less than the setpoint in d?</td>
<td>Y / N</td>
</tr>
<tr>
<td>g.</td>
<td>Is the pressure reading in f within 5% of pressure setpoint in e?</td>
<td>Y / N</td>
</tr>
<tr>
<td>h.</td>
<td>Did the system operation stabilize within 5 minutes after completion of step 2a?</td>
<td>Y / N</td>
</tr>
</tbody>
</table>

#### Step 3: System returned to initial operating conditions.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
</table>

### B. Testing Results

#### PASS / FAIL

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Select pass if either 1c or 1f are true.</td>
<td>□</td>
<td></td>
</tr>
<tr>
<td>Step 2: Select pass if 2b, 2e, 2f and 2g are true.</td>
<td>□</td>
<td></td>
</tr>
</tbody>
</table>

For SI units: 1 inch water column = 0.249 kPa
### CERTIFICATE OF ACCEPTANCE

**Hydronic System Variable Flow Control Acceptance**

<table>
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<tr>
<th>Project Name/Address:</th>
<th></th>
</tr>
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<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>

**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.

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
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<td></td>
</tr>
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<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
**FIELD TECHNICIAN’S DECLARATION STATEMENT**

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### Part B: Functional Testing

#### Step 1: Engage the demand shed controls.
- a. Engage the central demand shed control signal. 
  - Y / N
- b. Verify that the current operating temperature setpoint in a sample of noncritical spaces increases by the proper amount. 
  - Y / N
- c. Verify that the current operating temperature setpoint in a sample of critical spaces does not change. 
  - Y / N

#### Step 2: Disengage the demand shed controls.
- a. Disengage the central demand shed control signal. 
  - Y / N
- b. Verify that the current operating temperature setpoint in the sample of noncritical spaces returns to their original value. 
  - Y / N
- c. Verify that the current operating temperature setpoint in the sample of critical spaces does not change. 
  - Y / N

### Part C: Testing Results

Test passes if all answers are yes in Step 1 and Step 2.

### Part D: 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**

**MECH-12A**

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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**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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**Company Name:**

**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

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Name or Identification/Tag:</td>
<td>System Location or Area Served:</td>
</tr>
</tbody>
</table>

**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>Y / N</td>
</tr>
<tr>
<td>b. The unit shall include a factory-installed economizer and shall limit the economizer deadband 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 501.0 through Section E 505.1.4.2.</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</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>Supply air relative humidity</td>
</tr>
<tr>
<td>- Refrigerant suction temp</td>
<td>Outside air relative humidity</td>
</tr>
<tr>
<td>- Liquid line pressure</td>
<td>Return air relative humidity</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>Economizer enabled</td>
</tr>
<tr>
<td>- Heating enabled</td>
<td>Mixed air low limit cycle active</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
## Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units

### Project Name/Address: 

### System Name or Identification/Tag: 

### System Location or Area Served: 

#### B. Functional Testing.

**Step 1: Low airflow test.**

<table>
<thead>
<tr>
<th></th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Test low airflow condition by replacing the existing filter with a dirty filter or appropriate obstruction.</td>
</tr>
<tr>
<td>b.</td>
<td>Verify that the fault detection and diagnostics system reports the fault.</td>
</tr>
<tr>
<td>c.</td>
<td>Verify that the system is able to verify the correct refrigerant charge.</td>
</tr>
<tr>
<td>d.</td>
<td>Verify that you are able to calibrate the following:</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".
- **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 Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units and Zone Terminal Units Acceptance**

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th>System Name or Identification/Tag:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Enforcement Agency:</th>
<th>Permit Number:</th>
</tr>
</thead>
</table>

**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.
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<th>Company Name:</th>
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</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Field Technician’s Name:</th>
<th>Field Technician’s Signature:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>DateSigned:</th>
<th>Position with Company (Title):</th>
</tr>
</thead>
</table>

## Responsible Person’s Declaration Statement

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<th>Company Name:</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Responsible Person’s Name:</th>
<th>Responsible Person’s Signature:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>License:</th>
<th>Date Signed:</th>
<th>Position With Company (Title):</th>
</tr>
</thead>
</table>
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.

<table>
<thead>
<tr>
<th>Testing of each AHU with FDD controls shall include the following tests:</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1: Sensor Drift/Failure:</strong></td>
<td></td>
</tr>
<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>
<tr>
<td><strong>Step 2: Damper/actuator fault.</strong></td>
<td></td>
</tr>
<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>
<tr>
<td><strong>Step 3: Valve/actuator fault.</strong></td>
<td></td>
</tr>
<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>
<tr>
<td><strong>Step 4: Inappropriate simultaneous heating, mechanical cooling, and/or economizing.</strong></td>
<td></td>
</tr>
<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.

<table>
<thead>
<tr>
<th>Step 1: Sensor Drift/Failure:</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Disconnect the tubing to the differential pressure sensor of the VAV box.</td>
<td>Y / N</td>
</tr>
<tr>
<td>b. Verify that control system detects and reports the fault.</td>
<td>Y / N</td>
</tr>
<tr>
<td>c. Reconnect the sensor and verify proper sensor operation.</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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 2: Damper/actuator fault.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>If the damper is stuck open:</strong></td>
</tr>
<tr>
<td>a. Command the damper to be fully open (room temperature above setpoint).</td>
</tr>
<tr>
<td>b. Disconnect the actuator to the damper.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>d. Reconnect the actuator and restore to normal operation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>If the damper is stuck closed:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Set the damper to the minimum position.</td>
</tr>
<tr>
<td>b. Disconnect the actuator to the damper.</td>
</tr>
<tr>
<td>c. Set the cooling setpoint below the room temperature to simulate a call for cooling. Verify that the control system reports a fault.</td>
</tr>
<tr>
<td>d. Reconnect the actuator and restore to normal operation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 3: Valve/actuator fault (for systems with hydronic reheat).</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Command the reheat coil valve to full open.</td>
</tr>
<tr>
<td>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.</td>
</tr>
<tr>
<td>c. Reconnect the actuator and restore normal operation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4: Feedback loop tuning fault (unstable airflow).</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>b. The damper cycles continuously and airflow is unstable. Verify that the control system detects and reports the fault.</td>
</tr>
<tr>
<td>c. Reset the integral coefficient of the controller to the original value to restore normal operation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 5: Disconnected inlet duct.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>
### CERTIFICATE OF ACCEPTANCE

**MECH-13A**

**Automatic Fault Detection and Diagnostics (FDD) for Packaged Direct-Expansion Units and Zone Terminal Units Acceptance**

**APPENDIX E**

**Project Name/Address:**

**System Name or Identification/Tag:**

**System Location or Area Served:**

### C. Testing Results

<table>
<thead>
<tr>
<th>Test passes if all answers are yes under <strong>Functional Testing Sections.</strong></th>
<th>PASS / FAIL</th>
</tr>
</thead>
</table>

### D. 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

## Distributed Energy Storage DX AC Systems Acceptance

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th>System Name or Identification/Tag:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFORCEMENT AGENCY:</td>
<td>PERMIT NUMBER:</td>
<td>Note: Submit one Certificate of Acceptance for each system that must demonstrate compliance.</td>
</tr>
</tbody>
</table>

## 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>
<td></td>
<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>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESPONSIBLE PERSON’S NAME:</th>
<th>RESPONSIBLE PERSON’S SIGNATURE:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LICENSE:</th>
<th>DATE SIGNED:</th>
<th>POSITION WITH COMPANY (TITLE):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 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

| 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. | PASS / FAIL |
| | ☐ | ☐ |

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW
### CERTIFICATE OF ACCEPTANCE

**Distributed Energy Storage DX AC Systems Acceptance**

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Name or Identification/Tag:</td>
<td>System Location or Area Served:</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.

---

### Additional Information

- A section to provide detailed explanations for any failures or incomplete responses, allowing for any necessary documentation or attachments to be added.

---

**396**

**UNIFORM MECHANICAL CODE**
## CERTIFICATE OF ACCEPTANCE

**Thermal Energy Storage (TES) System Acceptance**

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th>System Location or Area Served:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Enforcement Agency:</th>
<th>Permit Number:</th>
</tr>
</thead>
</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>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Field Technician’s Name:</th>
<th>Field Technician’s Signature:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Date Signed:</th>
<th>Position with Company (Title):</th>
</tr>
</thead>
</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.
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<table>
<thead>
<tr>
<th>Company Name:</th>
<th>Phone:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Responsible Person’s Name:</th>
<th>Responsible Person’s Signature:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>License:</th>
<th>Date Signed:</th>
<th>Position With Company (Title):</th>
</tr>
</thead>
</table>
**APPENDIX E**

**CERTIFICATE OF ACCEPTANCE**

**Thermal Energy Storage (TES) System Acceptance**

<table>
<thead>
<tr>
<th>Project Name/Address:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System Name or Identification/Tag:</td>
<td>System Location or Area Served:</td>
</tr>
</tbody>
</table>

**Intent:** Verify proper operation of distributed energy storage DX systems.

**Construction Inspection**

I. 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>Type (centrifugal, reciprocating, etc):</td>
<td></td>
</tr>
<tr>
<td>Capacity (tons): (Size)</td>
<td></td>
</tr>
<tr>
<td>Starting Efficiency (kW/ton): (at beginning of ice production) (COMP-kW/TON-START)</td>
<td></td>
</tr>
<tr>
<td>Ending Efficiency (kW/ton): (at end of ice production) (COMP-kW/TON-END)</td>
<td></td>
</tr>
<tr>
<td>Capacity Reduction (% / F): (PER-COMP-REDUCT/F)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b. Storage Tank</th>
<th>Storage Type (Check): (TES-TYPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tanks (SIZE)</td>
<td></td>
</tr>
<tr>
<td>Storage Capacity per Tank (ton-hours)</td>
<td></td>
</tr>
<tr>
<td>Storage Rate (tons): (COOL-STORE-RATE)</td>
<td></td>
</tr>
<tr>
<td>Discharge Rate (tons): (COOL-SUPPLY-RATE)</td>
<td></td>
</tr>
<tr>
<td>Auxiliary Power (watts): (PUMP+AUX-kW)</td>
<td></td>
</tr>
<tr>
<td>Tank Area (square feet): (CTANK-LOSS-COEFF)</td>
<td></td>
</tr>
<tr>
<td>Tank Insulation (R-Value): (CTANK-LOSS-COEFF)</td>
<td></td>
</tr>
</tbody>
</table>

- Chilled Water Storage
- Ice-on-Coil
- CHS
- Ice Harvester
- Brine
- Ice-Slurry
- Eutectic Salt

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

**Results**

<table>
<thead>
<tr>
<th><strong>Step 1: TES System Design Verification</strong></th>
<th><strong>Results</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Y / N</td>
<td></td>
</tr>
</tbody>
</table>

#### 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 setpoint 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 setpoint 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 setpoint 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 setpoint above the ambient temperature. Verify that the tank does not discharge and the compressor is off.

**Results**

<table>
<thead>
<tr>
<th><strong>Step 2: TES System Controls and Operation Verification</strong></th>
<th><strong>Results</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td>Pass</td>
<td>Fail</td>
</tr>
<tr>
<td>Pass</td>
<td>Fail</td>
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<td>Pass</td>
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<tr>
<td>Pass</td>
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</tr>
<tr>
<td>Pass</td>
<td></td>
</tr>
</tbody>
</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.

For SI units: 1 metric ton = 1000 kg, 1000 British thermal units per hour = 0.293 kW
APPENDIX F
SIZING OF VENTING SYSTEMS SERVING APPLIANCES EQUIPPED WITH DRAFT HOODS, CATEGORY I APPLIANCES, AND APPLIANCES LISTED FOR USE WITH TYPE B VENTS.
(The content of this Appendix is based on Annex G and Annex J of NFPA 54)

F 101.0 Examples Using Single Appliance Venting Tables. [See Figure F 101.0(a) through Figure F 101.0(n)]

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(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(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(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 F 10.0(e)**
ASBESTOS CEMENT TYPE B OR SINGLE-WALL METAL VENT SYSTEM SERVING A SINGLE DRAFT HOOD-EQUIPPED APPLIANCE

Table 803.1.2(7) is used where sizing Type B double-wall gas vent connectors attached to a Type B double-wall common vent.

**Note:** Each appliance is permitted to be either Category I draft hood-equipped or fan-assisted type.

Table 803.1.2(8) is used where sizing single-wall vent connectors attached to a Type B double-wall common vent.

**FIGURE F 10.0(g)**
VENT SYSTEM SERVING TWO OR MORE APPLIANCES WITH TYPE B DOUBLE-WALL VENT AND SINGLE-WALL METAL VENT CONNECTORS

Table 803.1.2(9) is used where sizing Type B double-wall vent connectors 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(10) 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.

**FIGURE F 101.0(i)**
MASONRY CHIMNEY SERVING TWO OR MORE APPLIANCES WITH SINGLE-WALL METAL VENT CONNECTORS

Asbestos cement Type B or single-wall metal pipe vent serving two or more draft hood-equipped appliances. [See Table 803.1.2(11)]

**FIGURE F 101.0(j)**
ASBESTOS CEMENT TYPE B OR SINGLE-WALL METAL VENT SYSTEMS SERVING TWO OR MORE DRAFT HOOD-EQUIPPED APPLIANCES

Example: Manifolded common vent connector $L_M$ shall not exceed 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.

**Note:** This is an illustration of a typical manifolded vent connector. Different appliance, vent connector, or common vent types are possible.

**FIGURE F 101.0(k)**
USE OF MANIFOLDED COMMON VENT CONNECTORS

**FIGURE F 101.0(l)**
USE OF OFFSET COMMON VENT

Example: Offset common vent

**Note:** This is an illustration of a typical offset vent. Different appliance, vent connector, or vent types are possible.
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 F 101.1)

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:

   \[122 000 \text{ Btu/h (35.7 kW)} \times 0.90 = 110 000 \text{ Btu/h (32 kW)}\]

   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.

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) high Type B vent. 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 F 101.1)
(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 maximum vent capacity of 144 000 Btu/h (42 kW). The 80 000 Btu/h (23.4 kW) fan-assisted appliance is outside this range, so the conclusion is that a single-wall metal connector shall 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/h (21.1 kW) and 157 000 Btu/h (46 kW).

Where the appliance cannot be moved closer to the vertical vent, then a Type B vent shall 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/h (10.8 kW) and 150 000 Btu/h (44 kW).

Example 3: Interpolating Between Table Values. An installer has an 80 000 Btu/h (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 vent. 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) for a height of 12 feet (3658 mm), interpolation shall be used. Read down the 4 inch (102 mm) diameter NA T 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) + \( \frac{2}{5} \times 10 000 \) Btu/h (3 kW) = 81 000 Btu/h (23.7 kW). Therefore, a 4 inch (102 mm) diameter vent shall be used in the installation.

Examples Using Common Venting Tables. An installer has an 80 000 Btu/h (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 vent. Is this appliance permitted to be vented using a 4 inch (102 mm) diameter vent?

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
connectors and combined vent should be used in this installation? (See Figure F 102.1)

Solution:
Table 803.1.2(8) shall be used to size single-wall metal vent connectors attached to Type B vertical vents. In the vent connector capacity portion of Table 803.1.2(8), 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 be used with the water heater. For a draft hood-equipped furnace with a 3 foot (914 mm) rise, read across the 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 be used with the 150 000 Btu/h (44 kW) furnace. Since both vent connector horizontal lengths are less than the maximum lengths listed in Section 803.2.1, the table values shall be used without adjustments.

In the common vent capacity portion of Table 803.1.2(8), 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 185 000 Btu/h (54 kW), a 6 inch (152 mm) common vent shall be used.

**F 2-2 102.2 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 F 102.2)

Solution [See Table 803.1.2(8)]:

**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 803.1.2(8), the venting table values shall be used without adjustment. Using the Vent Connector Capacity portion of Table 803.1.2(8), 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 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 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 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 803.1.2(8), 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 the furnace has a fan-assisted combustion system, find the first FAN Max column with a Btu/h rating exceeding 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 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 shall be used without adjustment. Where the furnace had an input rating of 80 000 Btu/h (23.4 kW), then a Type B vent connector shall be needed in order to meet the minimum capacity limit. [See Table 803.1.2(7)]

**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 803.1.2(8), read down the 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 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.
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.

**F 2.3 102.3 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-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 803.1.2(10) is used to size common venting installations involving single-wall connectors into masonry chimneys.

**Water Heater Vent Connector Diameter.** Using Table 803.1.2(10), Vent Connector Capacity, read down the 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 the water heater input rating. The table shows that a 3 inch (76 mm) vent connector has a maximum input of 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 used.

**Furnace Vent Connector Diameter.** Using the Vent Connector Capacity portion of Table 803.1.2(10), 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 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 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.

**Masonry Chimney.** From Table F 102.3, the equivalent area for a nominal liner size of 8 inches (203 mm) by 12 inches (305 mm) is 63.6 of a square inch (0.041 m²). Using Table 803.1.2(10), 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 803.2.16 requires the common vent area to not exceed 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 inch (0.008 m²). Seven times 12.2 equals 85.4, which is exceeding 63.6, so this configuration is acceptable.

**F 2.4 102.4 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-vented 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 this exterior masonry chimney need to be relined? Where so, what corrugated metallic liner size is recommended? What vent connector diameters are recommended? [see Table F 102.3 and Figure 803.1.2(6)]

Solution:

According to Section 803.2.19, Type B vent connectors are required to be used with exterior masonry chimneys. Use Table 803.1.2(14) and Table 803.1.2(15) to size FAN+NAT common venting installations involving Type-B double-wall connectors into exterior masonry chimneys.

The local 99 percent winter design temperature needed to use Table 803.1.2(14) and Table 803.1.2(15) shall be found in the 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) column of Table 803.1.2(14) 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 appliance in this installation, 135 000 Btu/h (40 kW), is less than the maximum value, so this criterion is satisfied. Table 803.1.2(15), 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 shall be used, such as a Type B vent shown in Example 5(a) or a listed chimney liner system shown in the rest of the example.

According to Section 803.2.18, Table 803.1.2(7) or Table 803.1.2(8) are 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 803.1.2(7) 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 NAF Max column that is equal to or exceeding 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 exceeding 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) and is equal to the draft hood outlet diameter. A 4 inch (102 mm) vent connector is selected.

**Furnace Vent Connector Diameter:** Using Table 803.1.2(7), 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 exceeding 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 shall be permitted.

**Chimney Liner Diameter:** The total input to the common vent is 135 000 Btu/h (40 kW). Using the Common Vent

### TABLE F 102.3

**MASONRY CHIMNEY LINER DIMENSIONS WITH CIRCULAR EQUIVALENTS**

<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>
</tr>
</thead>
<tbody>
<tr>
<td>4 x 8</td>
<td>2½ x 6½</td>
<td>4.0</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0</td>
<td>19.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.0</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
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<td>7.0</td>
<td>38.3</td>
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<td>8 x 8</td>
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<td>8 x 12</td>
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<td></td>
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<td>1017.9</td>
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</table>

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.
Capacity portion of Table 803.1.2(7), 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 exceeding 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 803.1.2(7) 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 shall 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 shall be permitted to be redone using Table 803.1.2(8) 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.

### F 3.0 103.0 Example of Combination Indoor and Outdoor Combustion Air Opening

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 (4572 mm) by 30 foot (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.
   - Equipment room volume.
   - 15 feet (4572 mm) by 30 feet (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:
     
     \[
     100 000 \text{ Btu/h (29 kW)} + 40 000 \text{ Btu/h (11.7 kW)} = 140 000 \text{ Btu/h (41 kW)}
     \]
   - 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 F 103.0 the required volume for a 140 000 Btu/h (41 kW) water heater is 7000 cubic feet (198.22 m³).

3. Determine 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 combustion air is to come from outdoors. In this example, the combustion air opening directly communicates with the outdoors.

   \[
   140 000 \text{ Btu/h} = 47 \text{ square inches (0.03m²)}
   \]

6. Determine the minimum outdoor combustion air opening area.

   \[
   \text{Outdoor opening area} = 0.49 \text{ (from Step 4)} \times 47 \text{ square inches (0.03m²)} = 23 \text{ square inches (0.01m²)}
   \]

Section 701.7.3(3) requires the minimum dimension of the air opening shall be not less than 3 inches (76 mm).

**Conclusion:**

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.
### TABLE F 103.0
STANDARD METHOD: REQUIRED VOLUME, ALL APPLIANCES

<table>
<thead>
<tr>
<th>APPLIANCE INPUT (Btu/h)</th>
<th>REQUIRED VOLUME (cubic feet)</th>
</tr>
</thead>
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<tr>
<td>5000</td>
<td>250</td>
</tr>
<tr>
<td>10 000</td>
<td>500</td>
</tr>
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<td>15 000</td>
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<tr>
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<td>3500</td>
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<td>290 000</td>
<td>14 500</td>
</tr>
<tr>
<td>300 000</td>
<td>15 000</td>
</tr>
</tbody>
</table>

For SI units: 1000 British thermal units per hour = 0.293 kW, 1 cubic foot = 0.0283 m³
APPENDIX G
EXAMPLE CALCULATION OF OUTDOOR AIR RATE

G 101.0 Example Calculation of Outdoor Air Rate.

G 4.0 101.1 Example Calculation. (See Chapter 4 of this code for guidelines.)

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.

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:

\[ V_{ot} = \frac{R_p P_z + R_a A_z}{E_z} \]  
(Equation E 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 cubic foot per minute = 0.00047 m³/s
<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>UNIT</th>
<th>SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Meter</td>
<td>m</td>
</tr>
<tr>
<td>Mass</td>
<td>Kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Time</td>
<td>Second</td>
<td>s</td>
</tr>
<tr>
<td>Electric current</td>
<td>Ampere</td>
<td>A</td>
</tr>
<tr>
<td>Thermodynamic temperature</td>
<td>Kelvin</td>
<td>K</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>Mole</td>
<td>mol</td>
</tr>
<tr>
<td>Luminous intensity</td>
<td>Candela</td>
<td>cd</td>
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</table>

**SI SUPPLEMENTARY UNITS**

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<tr>
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<tr>
<td>Plane angle</td>
<td>Radian</td>
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</tr>
<tr>
<td>Solid angle</td>
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**SI PREFIXES**

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<thead>
<tr>
<th>MULTIPLICATION FACTOR</th>
<th>PREFIX</th>
<th>SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 000 000 000 000 000 = E+18</td>
<td>exa</td>
<td>E</td>
</tr>
<tr>
<td>1 000 000 000 000 000 = E+15</td>
<td>peta</td>
<td>P</td>
</tr>
<tr>
<td>1 000 000 000 000 000 = E+12</td>
<td>tera</td>
<td>T</td>
</tr>
<tr>
<td>1 000 000 000 000 000 = E+09</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>1 000 000 000 000 000 = E+06</td>
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<td>M</td>
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<td>k</td>
</tr>
<tr>
<td>100 000 000 000 000 = E+02</td>
<td>hecto</td>
<td>h</td>
</tr>
<tr>
<td>10 000 000 000 000 = E+01</td>
<td>deka</td>
<td>da</td>
</tr>
<tr>
<td>100 000 000 000 000 = E+00</td>
<td>deci</td>
<td>d</td>
</tr>
<tr>
<td>0.1 000 000 000 000 = E-01</td>
<td>centi</td>
<td>c</td>
</tr>
<tr>
<td>0.01 000 000 000 000 = E-02</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>0.001 000 000 000 000 = E-06</td>
<td>micro</td>
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<tr>
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<tr>
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</tr>
<tr>
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<tr>
<td>0.000 000 000 000 000 = E-18</td>
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### USEFUL TABLES

#### SI SYMBOLS AND PREFIXES

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<th>UNIT</th>
<th>SYMBOL</th>
<th>FORMULA</th>
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<tbody>
<tr>
<td>Frequency (of a periodic phenomenon)</td>
<td>hertz</td>
<td>Hz</td>
<td>l/s</td>
</tr>
<tr>
<td>Force</td>
<td>newton</td>
<td>N</td>
<td>kg•m/s²</td>
</tr>
<tr>
<td>Pressure, stress</td>
<td>pascal</td>
<td>Pa</td>
<td>N/m²</td>
</tr>
<tr>
<td>Energy, work, quantity of heat</td>
<td>joule</td>
<td>J</td>
<td>N•m</td>
</tr>
<tr>
<td>Power, radiant flux</td>
<td>watt</td>
<td>W</td>
<td>J/s</td>
</tr>
<tr>
<td>Quantity of electricity, electric charge</td>
<td>coulomb</td>
<td>C</td>
<td>A•s</td>
</tr>
<tr>
<td>Electric potential, potential difference,</td>
<td>volt</td>
<td>V</td>
<td>W/A</td>
</tr>
<tr>
<td>Electromotive force</td>
<td>farad</td>
<td>F</td>
<td>C/V</td>
</tr>
<tr>
<td>Capacitance</td>
<td>ohm</td>
<td>Ω</td>
<td>V/A</td>
</tr>
<tr>
<td>Conductance</td>
<td>siemens</td>
<td>S</td>
<td>A/V</td>
</tr>
<tr>
<td>Magnetic flux</td>
<td>weber</td>
<td>Wb</td>
<td>V•s</td>
</tr>
<tr>
<td>Magnetic flux density</td>
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<td>T</td>
<td>Wb/m²</td>
</tr>
<tr>
<td>Inductance</td>
<td>henry</td>
<td>H</td>
<td>Wb/A</td>
</tr>
<tr>
<td>Luminous flux</td>
<td>lumen</td>
<td>lm</td>
<td>cd•sr</td>
</tr>
<tr>
<td>Illuminance</td>
<td>lux</td>
<td>lx</td>
<td>lm/m²</td>
</tr>
<tr>
<td>Activity (of radionuclides)</td>
<td>becquerel</td>
<td>Bq</td>
<td>l/s</td>
</tr>
<tr>
<td>Absorbed dose</td>
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<td>Gy</td>
<td>J/kg</td>
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#### CONVERSION FACTORS

<table>
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<tr>
<th>TO CONVERT</th>
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<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LENGTH</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 mile (U.S. statute)</td>
<td>km</td>
<td>1.609344</td>
</tr>
<tr>
<td>1 yd</td>
<td>m</td>
<td>0.9144</td>
</tr>
<tr>
<td>1 ft</td>
<td>m</td>
<td>0.3048</td>
</tr>
<tr>
<td></td>
<td>mm</td>
<td>304.8</td>
</tr>
<tr>
<td>1 in</td>
<td>mm</td>
<td>25.4</td>
</tr>
<tr>
<td><strong>AREA</strong></td>
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<td></td>
</tr>
<tr>
<td>1 mile² (U.S. statute)</td>
<td>km²</td>
<td>2.589988</td>
</tr>
<tr>
<td>1 acre (U.S. survey)</td>
<td>ha</td>
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<tr>
<td></td>
<td>m²</td>
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<td>m²</td>
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</tr>
<tr>
<td>1 ft²</td>
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</tr>
<tr>
<td>1 in²</td>
<td>m²</td>
<td>0.000645</td>
</tr>
<tr>
<td><strong>VOLUME, MODULUS OF SECTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 acre ft</td>
<td>m³</td>
<td>1233.489</td>
</tr>
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<td>1 yd³</td>
<td>m³</td>
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<td>m³</td>
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<tr>
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<td>m³</td>
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<tr>
<td></td>
<td>mm³</td>
<td>16387.06</td>
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<tr>
<td>1 barrel (42 U.S. gallons)</td>
<td>L</td>
<td>158.9873</td>
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### (FLUID) CAPACITY

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<thead>
<tr>
<th>TO CONVERT</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1 gal (U.S. Liquid)**</td>
<td>L*</td>
<td>3.785</td>
</tr>
<tr>
<td>1 qt (U.S. Liquid)</td>
<td>L</td>
<td>0.9463529</td>
</tr>
<tr>
<td>1 pt (U.S. Liquid)</td>
<td>L</td>
<td>0.4731765</td>
</tr>
<tr>
<td>1 fl oz (U.S.)</td>
<td>mL</td>
<td>29.57353</td>
</tr>
<tr>
<td>1 gal (U.S. Liquid)</td>
<td>m³</td>
<td>0.003785</td>
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</table>

**1 gallon (UK) approx. 1.2 gal (U.S.), *1 liter = 0.001 cubic meters**

### SECOND MOMENT OF AREA

<table>
<thead>
<tr>
<th>TO CONVERT</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in⁴</td>
<td>mm⁴</td>
</tr>
<tr>
<td></td>
<td>m⁴</td>
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### PLANE ANGLE

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<td>1° (degree)</td>
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</tr>
<tr>
<td></td>
<td>mrad</td>
</tr>
<tr>
<td>1' (minute)</td>
<td>rad</td>
</tr>
<tr>
<td>1&quot; (second)</td>
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### VELOCITY, SPEED

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<td>1 ft/s</td>
<td>m/s</td>
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<tr>
<td>1 mile/h</td>
<td>km/h</td>
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<td>m/s</td>
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### VOLUME RATE OF FLOW

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</tr>
</thead>
<tbody>
<tr>
<td>1 ft³/min</td>
<td>m³/s</td>
</tr>
<tr>
<td>1 gal/min</td>
<td>L/s</td>
</tr>
<tr>
<td>1 gal/min</td>
<td>L/s</td>
</tr>
<tr>
<td></td>
<td>m³/min</td>
</tr>
<tr>
<td></td>
<td>m³/s</td>
</tr>
<tr>
<td>1 gal/day</td>
<td>L/s</td>
</tr>
<tr>
<td>1 acre ft/s</td>
<td>m³/s</td>
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### TEMPERATURE INTERVAL

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<tr>
<th>C</th>
<th>°F</th>
<th>°K</th>
</tr>
</thead>
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<td>°C</td>
<td>°K</td>
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### EQUIVALENT TEMPERATURE

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<th>°K</th>
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<tbody>
<tr>
<td>°F</td>
<td>°C</td>
<td>°K</td>
</tr>
<tr>
<td>°C</td>
<td>°F</td>
<td>°K</td>
</tr>
<tr>
<td></td>
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### MASS

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</thead>
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<tr>
<td>1 short ton (2000 lb)</td>
<td>kg</td>
</tr>
<tr>
<td>1 metric ton</td>
<td>kg</td>
</tr>
<tr>
<td>1 lb</td>
<td>kg</td>
</tr>
<tr>
<td>1 oz</td>
<td>kg</td>
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### MASS PER UNIT AREA

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</thead>
<tbody>
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<tr>
<td>1 oz/in²</td>
<td>kg/m²</td>
</tr>
<tr>
<td>1 oz/ft²</td>
<td>kg/m²</td>
</tr>
</tbody>
</table>
### Conversion Factors

#### Density (Mass per Unit Volume)

<table>
<thead>
<tr>
<th>TO CONVERT</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lb/ft³</td>
<td>kg/m³</td>
<td>16.0184</td>
</tr>
<tr>
<td>1 lb/in³</td>
<td>kg/m³</td>
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<tr>
<td>1 lb/yd³</td>
<td>kg/m³</td>
<td>0.5932764</td>
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#### Force

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<th>TO CONVERT</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 tonf (ton-force) (2000 lbf)</td>
<td>kN</td>
<td>8.896443</td>
</tr>
<tr>
<td>1 kip (1,000 lbf)</td>
<td>kN</td>
<td>4.448222</td>
</tr>
<tr>
<td>1 lbf (pound-force)</td>
<td>N</td>
<td>4.4482</td>
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#### Moment of Force, Torque

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<tr>
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<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lbf•ft</td>
<td>N•m</td>
<td>1.355818</td>
</tr>
<tr>
<td>1 lbf•in</td>
<td>N•m</td>
<td>0.1129848</td>
</tr>
<tr>
<td>1 tonf•ft</td>
<td>kN•m</td>
<td>2.71342</td>
</tr>
<tr>
<td>1 kip•ft</td>
<td>kN•m</td>
<td>1.35671</td>
</tr>
</tbody>
</table>

#### Force per Unit Length

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<tr>
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<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lbf/ft</td>
<td>N/m</td>
<td>14.5939</td>
</tr>
<tr>
<td>1 lbf/in</td>
<td>N/m</td>
<td>175.1268</td>
</tr>
<tr>
<td>1 tonf/ft</td>
<td>kN/m</td>
<td>2916867</td>
</tr>
</tbody>
</table>

#### Pressure, Stress, Modulus of Elasticity (Force per Unit Area) (1 Pa = 1 N/m²)

<table>
<thead>
<tr>
<th>TO CONVERT</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 tonf/in²</td>
<td>MPa</td>
<td>13.7895</td>
</tr>
<tr>
<td>1 tonf/ft²</td>
<td>kPa</td>
<td>95.7605</td>
</tr>
<tr>
<td>1 kip/in²</td>
<td>MPa</td>
<td>6.8947</td>
</tr>
<tr>
<td>1 lbf/in²</td>
<td>kPa</td>
<td>6.89476</td>
</tr>
<tr>
<td>1 lbf/ft²</td>
<td>Pa</td>
<td>47.88026</td>
</tr>
</tbody>
</table>

Atmosphere | kPa | 101.325 |

<table>
<thead>
<tr>
<th>TO CONVERT</th>
<th>TO</th>
<th>MULTIPLY BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch mercury (32°F)</td>
<td>kPa</td>
<td>3.3863</td>
</tr>
<tr>
<td>1 inch (water column at 60°F)</td>
<td>kPa</td>
<td>0.24884</td>
</tr>
</tbody>
</table>

#### Work, Energy, Heat (1J = 1N•m = 1W•s)

<table>
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<tr>
<th>TO CONVERT</th>
<th>TO</th>
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<tr>
<td>1 Btu/h (Int. Table)</td>
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<td>1 ft•lbf</td>
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<td>1 Btu/ft²•°F</td>
<td>W/(m²•K)</td>
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#### Coefficient of Heat Transfer

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<tr>
<td>1 Btu/(h•ft²•°F)</td>
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#### Thermal Conductivity

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<tr>
<td>1 lm/ft² (footcandle)</td>
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#### Illuminance

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<tbody>
<tr>
<td>1 cd/in²</td>
<td>cd/m²</td>
<td>1.550003E+03</td>
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<tr>
<td>1 foot lambert</td>
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<tr>
<td>1 lambert</td>
<td>cd/m²</td>
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<table>
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<tr>
<th>Manufacturer's Standard Gauge No.</th>
<th>Decimal and Nominal Thickness Equivalent (inch)</th>
<th>Recommended Minimum Thickness Equivalent* (inch)</th>
<th>Galvanized Sheet Gauge No.</th>
<th>Decimal and Nominal Thickness Equivalent (inch)</th>
<th>Recommended Minimum Thickness Equivalent* (inch)</th>
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<td>30</td>
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</table>

For SI units: 1 inch = 25.4 mm

* The thickness of the sheets set forth in the code correspond to the thickness shown under these columns. They are the approximate minimum thicknesses and are based on the following references:

  - Carbon Sheet Steel—Thickness 0.071 inch (1.803 mm) and over:
    - ASTM A568, Table 3, Thickness Tolerances of Hot-Rolled Sheet (Carbon Steel).
  - Carbon Sheet Steel—Thickness less than 0.071 inch (1.803 mm):
    - ASTM A568, Table 23, Thickness Tolerances of Cold-Rolled Sheet (Carbon and High-Strength Low Alloy).
  - Galvanized Sheet Steel—All thicknesses:
    - ASTM A653, Table 4, Thickness Tolerances of Hot-Dip Galvanized Sheet.

Minimum thickness is the difference between the thickness equivalent of each gauge and the maximum negative tolerance for the widest rolled width.
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