

APPENDIX C
CODE CHANGE PROPOSAL
NORTH CAROLINA
BUILDING CODE COUNCIL

B-4

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Granted by BCC _____ Petition for Rule Making Item Number _____
Denied by BCC _____ Adopted by BCC _____ Approved by RRC _____
Disapproved by BCC _____ Objection by RRC _____

PROPONENT: Natalie MacDonald, Chair of the BCC Mechanical Standing Committee PHONE: (919) 888-0284

REPRESENTING: BCC Mechanical Standing Committee

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North Carolina State Building Code, Volume 2024 NC Residential Code-Chapter 12-24 Section _____

CHECK ONE: [] Revise section to read as follows: [] Delete section and substitute the following:
[X] Add new section to read as follows: [] Delete section without substitution:

~~LINE THROUGH MATERIAL TO BE DELETED~~

UNDERLINE MATERIAL TO BE ADDED

Please type. Continue proposal or reason on plain paper attached to this form. See reverse side for instructions.

The 2024 NCRC-Chapter 12 through 24 is based on Chapter 12 through 24 of the 2021 IRC which can be viewed at: [Digital Codes \(iccsafe.org\)](https://www.iccsafe.org)

The NC amendments to Chapter 12 through 24 of the 2021 IRC that make up 2024 NCRC-Chapter 12 through 24 are shown in ATTACHMENT A below

Will this proposal change the cost of construction? Decrease [] Increase [] No [X]

Will this proposal increase to the cost of a dwelling by \$80 or more? Yes [] No [X]

Will this proposal affect the Local or State funds? Local [] State [] No [X]

Will this proposal cause a substantial economic impact (\geq \$1,000,000)? Yes [] No [X]

- Non-Substantial – Provide an economic analysis including benefit/cost estimates.
- Substantial – The economic analysis must also include 2-alternatives, time value of money and risk analysis.
- Pursuant to §143-138(a1)(2) a cost-benefit analysis is required for all proposed amendments to the NC Energy Conservation Code. The Building Code Council shall also require same for the NC Residential Code, Chapter 11.

REASON: This amendment is proposed to protect the public by updating the code to current standards of practice.

BCC CODE CHANGES

Signature: CARL MARTIN

Date: May 1, 2023

FORM 11/26/19

ATTACHMENT A

THIS DOCUMENT CONTAINS PROPOSED NORTH CAROLINA AMENDMENTS TO THE 2021 EDITION OF THE INTERNATIONAL RESIDENTIAL CODE (IRC) FOR THE PURPOSE OF ESTABLISHING THE 2024 EDITION OF THE NORTH CAROLINA RESIDENTIAL CODE.

UNDERLINED TEXT INDICATE NORTH CAROLINA PROPOSED AMENDMENTS TO THE 2021 INTERNATIONAL RESIDENTIAL CODE FOR THE 2024 NORTH CAROLINA RESIDENTIAL CODE.

~~STRUCKTHROUGH~~ TEXT INDICATES IRC TEXT THAT IS PROPOSED TO BE REMOVED FROM THE 2024 NORTH CAROLINA RESIDENTIAL CODE.

TEXT THAT IS HIGHLIGHTED IN **YELLOW** INDICATES PROPOSED NORTH CAROLINA AMENDMENTS THAT ARE NEW OR DIFFERENT THAN THE 2018 NORTH CAROLINA RESIDENTIAL CODE.

User notes:

About this chapter: Chapter 12 supplements Chapter 1 and establishes the scope of coverage for Chapters 13 through 24. The applicability of code provisions to existing mechanical systems and appliances is established herein.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M1201.1 (101.1) Scope. The provisions of Chapters 12 through 24 shall regulate the design, installation, maintenance, alteration and inspection of mechanical systems that are permanently installed and used to control environmental conditions within buildings. These chapters shall also regulate those mechanical systems, system components, equipment and appliances specifically addressed in this code.

M1201.2 Application. In addition to the general administration requirements of Chapter 1, the administrative provisions of this chapter shall apply to the mechanical requirements of Chapters 13 through 24.

M1202.1 (102.4) Additions, alterations or repairs. Additions, alterations, renovations or repairs to a mechanical system shall conform to the requirements for a new mechanical system without requiring the existing mechanical system to comply with all of the requirements of this code. Additions, alterations or repairs shall not cause an existing mechanical system to become unsafe, hazardous or overloaded. Minor additions, alterations or repairs to existing mechanical systems shall meet the provisions for new construction, unless such work is done in the same manner and arrangement as was in the existing system, is not hazardous, and is approved.

M1202.2 (102.2) Existing installations. Except as otherwise provided for in this code, a provision in this code shall not require the removal, alteration or abandonment of, nor prevent the continued use and maintenance of, an existing mechanical system lawfully in existence at the time of the adoption of this code.

M1202.3 (102.3) Maintenance. Mechanical systems, both existing and new, and parts thereof shall be maintained in proper operating condition in accordance with the original design and in a safe and sanitary condition. Devices or safeguards that are required by this code shall be maintained in compliance with the code edition under which such devices and safeguards were installed. The owner or the owner's designated agent shall be responsible for maintenance of the mechanical systems. To determine compliance with this provision, the building official shall have the authority to require a mechanical system to be reinspected. Deleted.

M1202.4 (102.6) Historic buildings.

The provisions of this code relating to the construction, alteration, repair, enlargement, restoration, relocation or moving of buildings or structures shall not be mandatory for existing buildings or structures identified and classified by the state or local jurisdiction as historic buildings where such buildings or structures are judged by the code official to be safe and in the public interest of health, safety and welfare regarding any proposed construction, alteration, repair, enlargement, restoration, relocation or moving of buildings.

User notes:

About this chapter: Chapter 13 contains general requirements that apply broadly and that would not be at home in other chapters that address specific subject matter. Coverage includes: Testing and certification of materials, installation requirements, listing and labeling, access to appliances, clearances to combustibles, and protection of mechanical systems and the building structure.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M1301.1 Flood-resistant installation. In flood hazard areas as established by Table R301.2, mechanical appliances, equipment and systems shall be located or installed in accordance with Section R322.1.6.

M1301.2 (301.3) Identification. Each length of pipe and tubing and each pipe fitting utilized in a mechanical system shall bear the identification of the manufacturer as required by the listing or standard for the piping or tubing.

M1301.3 Installation of materials. Materials shall be installed in strict accordance with the standards under which the materials are accepted and approved. In the absence of such installation procedures, the manufacturer's instructions shall be followed. Where the requirements of referenced standards or manufacturer's instructions do not conform to minimum provisions of this code, the provisions of this code shall apply.

M1301.4 (301.4) Plastic pipe, fittings and components. Plastic pipe, fittings and components shall be third-party certified as conforming to NSF 14. Deleted, and meet the applicable standards listed in this code for the specific service use.

M1301.5 Third-party testing and certification. Piping, tubing and fittings shall comply with the applicable referenced standards, specifications and performance criteria of this code and shall be identified in accordance with Section M1301.2. Piping, tubing and fittings shall either be tested by an approved third-party testing agency or certified by an approved third-party certification agency.

M1302.1 (301.7) Listed and labeled. Appliances regulated by this code shall be listed and labeled for the application in which they are installed and used, unless otherwise approved in accordance with Section R104.11105 of the *North Carolina Administrative Code and Policies*.

Exceptions:

1. Listing and labeling of equipment and appliances used for refrigeration shall be in accordance with Section 1101.2 of the *North Carolina Mechanical Code*.
2. Field erected equipment shall be deemed acceptable, provided it is assembled using listed components and parts, if the design thereof is by a registered design professional.

M1303.1 (301.9) Label information. A permanent factory-applied nameplate(s) shall be affixed to appliances on which shall appear, in legible lettering, the manufacturer's name or trademark, the model number, a serial number and the seal or mark of the testing agency. A label also shall include the following:

1. Electrical appliances. Electrical rating in volts, amperes and motor phase; identification of individual electrical components in volts, amperes or watts and motor phase; and in Btu/h (W) output and required clearances.
2. Absorption units. Hourly rating in Btu/h (W), minimum hourly rating for units having step or automatic modulating controls, type of fuel, type of refrigerant, cooling capacity in Btu/h (W) and required clearances.
3. Fuel-burning units. Hourly rating in Btu/h (W), type of fuel approved for use with the appliance and required clearances.

4. Electric comfort-heating **appliances**. The electric rating in volts, amperes and phase; Btu/h (W) output rating; individual marking for each electrical component in amperes or watts, volts and phase; and required clearances from combustibles.
5. Maintenance instructions. Required regular maintenance actions and title or publication number for the operation and maintenance manual for that particular model and type of product.

M1304.1 (301.12) Fuel types. Fuel-fired *appliances* shall be designed for use with the type of fuel to which they will be connected and the altitude at which they are installed. *Appliances* that comprise parts of the building mechanical system shall not be converted for the use of a different fuel, except where *approved* and converted in accordance with the manufacturer's instructions. The fuel input rate shall not be increased or decreased beyond the limit rating for the altitude at which the *appliance* is installed.

M1305.1 (306.1) Appliance access for inspection service, repair and replacement. *Appliances* shall be **located to allow for access for** inspection, service, repair and replacement without removing permanent construction, other *appliances*, or any other piping or ducts not connected to the *appliance* being inspected, serviced, repaired or replaced. A level working space not less than 30 inches deep and 30 inches wide (762 mm by 762 mm) shall be provided in front of the control side to service an *appliance*.

M1305.1.1 (306.1.1) Furnaces and air handlers. Deleted.

M1305.1.1 (306.2) Appliances in rooms. *Appliances* installed in a compartment, alcove, *basement* or similar space shall be accessed by an opening or door and an unobstructed passageway measuring not less than 24 inches (610 mm) wide and large enough to allow removal of the largest *appliance* in the space, provided there is a level service space of not less than 30 inches (762 mm) deep and the height of the *appliance*, but not less than 30 inches (762 mm), at the front or service side of the *appliance* with the door open.

M1305.1.2 (306.3) Appliances in attics and above hard ceilings. *Attics* containing *appliances* shall be provided with an opening and a clear and unobstructed passageway large enough to allow removal of the largest component of the appliance, but not less than 30 inches (762 mm) high and 22 inches (559 mm) wide and not more than 20 feet (6096 mm) long measured along the centerline of the passageway from the opening to the *appliance*. The passageway shall have continuous solid flooring in accordance with Chapter 5 not less than 24 inches (610 mm) wide. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present along all sides of the *appliance* where access is required. The clear access opening dimensions shall be not less than of 20 inches by 30 inches (508 mm by 762 mm), and large enough to allow removal of the largest component of the appliance *appliance*.

Exceptions:

1. The passageway and level service space are not required where the *appliance* (or disassembled appliance) can be serviced and removed through the required opening.
2. Where the passageway is unobstructed and not less than 6 feet (1829 mm) high and 22 inches (559 mm) wide for its entire length, the passageway shall be not more than 50 feet (15 250 mm) long. Where the passageway is not less than 6 feet (1829 mm) high for its entire length, the passageway shall not be limited in length.

M1305.1.2.1 (306.3.1) Electrical requirements. A luminaire controlled by a switch located at the required passageway opening and a receptacle outlet shall be installed at or near the *equipment or appliance* location in accordance with ~~Chapter 39~~ the North Carolina Electrical Code. Exposed lamps shall be protected from damage by location or lamp guards. ~~lighting outlet and receptacle. For reference and coordination purposes only, refer to the North Carolina Electrical Code, Article 210.63 for receptacles, and Article 210.70 (C) for lighting outlet and switch locations.~~

M1305.1.3 (306.4) Appliances under floors and exterior grade installations. Underfloor spaces containing *appliances* shall be provided with an unobstructed passageway large enough to remove the largest component of the appliance, but not less than 30 inches (762 mm) high and 22 inches (559 mm) wide 22 inches (559 mm) high and 36 inches (914 mm) wide, nor more than 20 feet (6096 mm) long measured along the centerline of the passageway from the opening to the *appliance*. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the *appliance*. If the depth of the passageway or the service space exceeds 12 inches (305 mm) below the adjoining grade, the walls of the passageway shall be lined with concrete or masonry extending 4 inches (102 mm) above the adjoining grade in accordance with Chapter 4. The rough-framed access opening dimensions shall be not less than 22 inches high by 30 inches wide (559 mm by 762 mm), and large enough to remove the largest component of the appliance.

Exceptions:

1. The passageway is not required where the level service space is present when the access is open, and the *appliance* can be serviced and removed through the required opening.
2. ~~Where the passageway is unobstructed and not less than 6 feet (1829 mm) high and 22 inches (559 mm) wide for its entire length, the passageway shall not be limited in length. Where the passageway is not less than 6 feet (1829 mm) high for its entire length, the passageway shall not be limited in length.~~

M1305.1.3.1 (304.10.1) Ground clearance. *Equipment* and *appliances* supported from the ground shall be level and firmly supported on a concrete slab or other *approved* material extending not less than 3/2 inches (76 mm) above the adjoining ground. Such support shall be in accordance with the manufacturer's installation instructions. *Appliances* suspended from the floor shall have a clearance of not less than 6 inches (152 mm) from the ground.

~~**M1305.1.43.1.1 (304.10.1) Exterior grade installations.** Equipment and appliances installed above grade level shall be supported on a solid base or approved material a minimum of 2 inches (51 mm) thick.~~

~~**M1305.1.43.1.2 (304.10.2) Under floor installation.** Suspended equipment shall be a minimum of 6 inches (152 mm) above the adjoining grade. See Section M1601.4.8 for ductwork support heights.~~

~~**M1305.1.43.1.3 (304.10.3) Crawl space supports.** A support shall be provided at each corner of the unit not less than 8 inches by 8 inches (203.2 mm by 203.2 mm). The unit shall be supported a minimum of 2 inches (51 mm) above grade. When constructed of brick, the bricks shall be mortared together. All units stacked shall be mortared together. Fabricated units, formed concrete, or other approved materials shall be permitted.~~

~~**M1305.1.43.1.4 (304.10.4) Drainage.** Below grade installations shall be provided with a natural drain or an automatic lift or sump pump. For pit requirements, see Section M1305.1.43.2.~~

M1305.1.3.2 Pit locations. Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil and shall be installed not less than 3/2 inches (76 mm) above the pit floor. The sides of the pit or excavation shall be held back not less than 12 inches (305 mm) from the *appliance*. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry. Such concrete or masonry shall extend not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. Excavation on the control side of the *appliance* shall extend horizontally not less than 30 inches (762 mm). The *appliance* shall be protected from flooding in an *approved* manner.

~~**M1305.1.43.2 (303.7) Pit locations.** Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil. The sides of the pit or excavation shall be held back not less than 12 inches (305 mm) from the *appliance*. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry. Such concrete or masonry shall extend not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load bearing capacity to resist collapse. The *appliance* shall be protected from flooding in an *approved* manner.~~

M1305.1.3.3 Electrical requirements. A luminaire controlled by a switch located at the required passageway opening and a receptacle outlet shall be installed at or near the equipment or appliance location in accordance with Chapter 39 the North Carolina Electrical Code. Exposed lamps shall be protected from damage by location or lamp guards.

M1306.1 (304.9) Appliance clearance. ~~Appliances shall be installed with the clearances from unprotected combustible materials as indicated on the appliance label and in the manufacturer's installation instructions.~~ Heat-producing equipment and appliances shall be installed to maintain the required clearances to combustible construction as specified in the listing and manufacturer's instructions. Such clearances shall be reduced only in accordance with Section M1306. Clearances to combustibles shall include such considerations as door swing, drawer pull, overhead projections or shelving and window swing, shutters, coverings and drapes. Devices such as doorstops or limits, closers, drapery ties or guards shall not be used to provide the required clearances.

M1306.2 Clearance reduction. The reduction of required clearances to combustible assemblies or combustible materials shall be based on Section M1306.2.1 or M1306.2.2.

M1306.2.1 (308.4.1) Labeled assemblies. ~~The allowable clearance shall be based on an approved reduced clearance protective assembly that is listed and labeled in accordance with UL 1618.~~ The allowable clearance reduction shall be based on an approved reduced clearance protective assembly that has been tested and bears the label of an approved agency.

M1306.2.2 (308.4.2) Reduction table. Reduction of clearances shall be in accordance with the appliance manufacturer's instructions and Table M1306.2. Forms of protection with ventilated airspace shall conform to the following requirements:

1. Not less than 1-inch (25 mm) airspace shall be provided between the protection and combustible wall surface.
2. Air circulation shall be provided by having edges of the wall protection open not less than 1 inch (25 mm).
3. If the wall protection is mounted on a single flat wall away from corners, air circulation shall be provided by having the bottom and top edges, or the side and top edges not less than 1 inch (25 mm).
4. Wall protection covering two walls in a corner shall be open at the bottom and top edges not less than 1 inch (25 mm).

TABLE M1306.2

REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION^{a, c, d, e, f, g, h, i, j, k, l}

TYPE OF PROTECTION APPLIED TO AND COVERING ALL SURFACES OF COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION (See Figures M1306.1 and M1306.2)	WHERE THE REQUIRED CLEARANCE WITHOUT PROTECTION FROM APPLIANCE, VENT CONNECTOR, OR SINGLE-WALL METAL PIPE IS:									
	36 inches		18 inches		12 inches		9 inches		6 inches	
	Allowable clearances with specified protection (Inches) ^b									
	Use Column 1 for clearances above an appliance or horizontal connector. Use column 2 for clearances from an appliance, vertical connector and single-wall metal pipe.									
	Above column 1	Sides and rear column 2	Above column 1	Sides and rear column 2	Above column 1	Sides and rear column 2	Above column 1	Sides and rear column 2	Above column 1	Sides and rear column 2
3 1/2-inch-thick masonry wall without ventilated airspace	—	24	—	12	—	9	—	6	—	5
1/2-inch insulation board over 1-inch glass fiber or mineral wool batts	24	18	12	9	9	6	6	5	4	3
Galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) over 1-inch glass fiber or mineral wool batts reinforced with wire or rear face with a ventilated airspace	18	12	9	6	6	4	5	3	3	3
3 1/2-inch-thick masonry wall with ventilated airspace	—	12	—	6	—	6	—	6	—	6
Galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) with a ventilated airspace 1 inch off the combustible assembly	18	12	9	6	6	4	5	3	3	2

1/2-inch-thick insulation board with ventilated airspace	18	12	9	6	6	4	5	3	3	3
Galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) with ventilated airspace over 24 gage sheet steel with a ventilated space	18	12	9	6	6	4	5	3	3	3
1-inch glass fiber or mineral wool batts sandwiched between two sheets of galvanized sheet steel having a minimum thickness of 0.0236-inch (No. 24 gage) with a ventilated airspace	18	12	9	6	6	4	5	3	3	3

TYPE OF PROTECTIVE ASSEMBLY ^a	REDUCED CLEARANCE WITH PROTECTION (inches) ^b							
	Horizontal combustible assemblies located above the heat source				Horizontal combustible assemblies located beneath the heat source and all vertical combustible assemblies			
	Required clearance to combustibles without protection (inches) ^a				Required clearance to combustibles without protection (inches)			
	36	18	9	6	36	18	9	6
Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), mounted on 1-inch glass fiber or mineral wool batt reinforced with wire on the back, 1 inch off the combustible assembly	18	9	5	3	12	6	3	2
Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	2
Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having a 1-inch airspace between layers, spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	2
Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having 1 inch of fiberglass insulation between layers, spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	2
0.5-inch inorganic insulating board, over 1 inch of fiberglass or mineral wool batt, against the combustible assembly	24	12	6	4	18	9	5	3
3 1/2-inch brick wall, spaced 1 inch off the combustible wall	12	6	6	6	12	6	6	6
3 1/2-inch brick wall, against the combustible wall	24	12	6	5	24	12	6	5

For SI: 1 inch = 25.4 mm, 1 pound per cubic foot = 16.019 kg/m³, °C = [(°F) - 32]/1.8, 1 Btu/(h × ft² × °F/in.) = 0.001442299 (W/cm² × °C/cm).

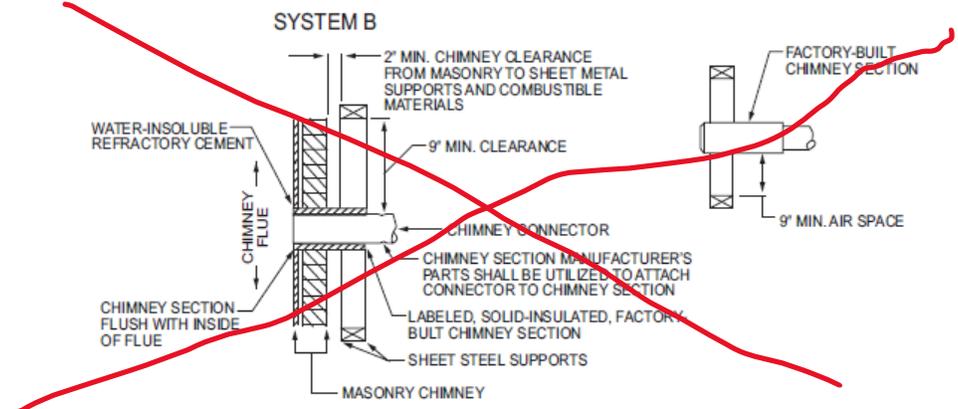
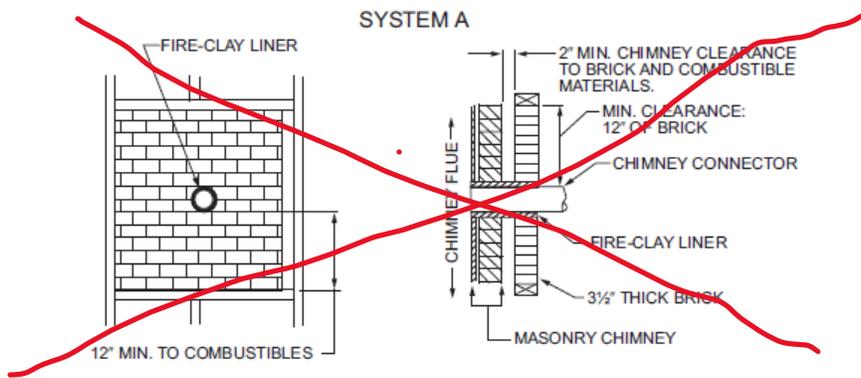
a. Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.

- b. Clearances shall be measured from the surface of the heat-producing appliance or equipment to the outer surface of the combustible material or combustible assembly.
- c. Spacers and ties shall be of noncombustible material. Spacers and ties shall not be used directly opposite appliance or connector.
- d. Where all clearance reduction systems use a ventilated airspace, adequate provision for air circulation shall be provided as described (see Figures M1306.1 and M1306.2).
- e. There shall be not less than 1 inch between clearance reduction systems and combustible walls and ceilings for reduction systems using ventilated airspace.
- f. If a wall protector is mounted on a single flat wall away from corners, adequate air circulation shall be permitted to be provided by leaving only the bottom and top edges or only the side and top edges open with not less than a 1-inch air gap.
- g. Mineral wool and glass fiber batts (blanket or board) shall have a minimum density of 8 pounds per cubic foot and a minimum melting point of 1,500°F.
- h. Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu inch per square foot per hour °F or less. Insulation board shall be formed of noncombustible material.
- i. There shall be not less than 1 inch between the appliance and the protector. The clearance between the appliance and the combustible surface shall not be reduced below that allowed in this table.
- j. All clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
- k. Listed single-wall connectors shall be permitted to be installed in accordance with the terms of their listing and the manufacturer's instructions.
- l. For limitations on clearance reduction for solid-fuel-burning appliances, see Section M1306.2.3.

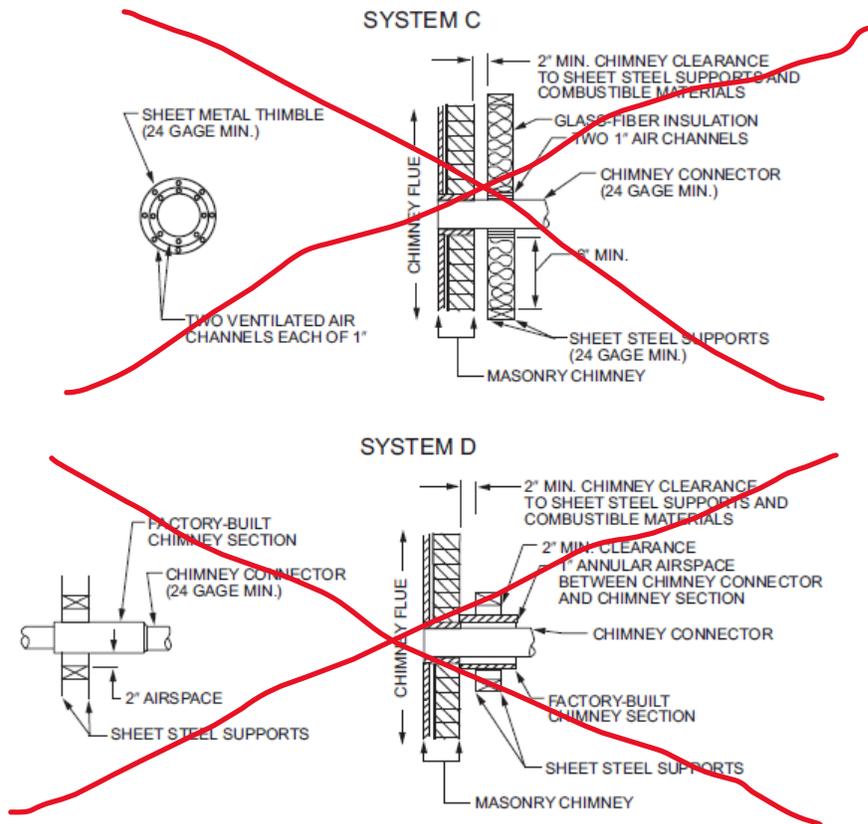
M1306.2.3 Solid-fuel appliances. Table M1306.2 shall not be used to reduce the clearance required for solid-fuel appliances *listed* for installation with minimum clearances of 12 inches (305 mm) or less. For appliances *listed* for installation with minimum clearances greater than 12 inches (305 mm), Table M1306.2 shall not be used to reduce the clearance to less than 12 inches (305 mm).

M1306.2.4 (308.4.2.2) Masonry chimneys. The *clearance* reduction methods specified in Table M1306.2 shall not be utilized to reduce the *clearances* required for masonry *chimneys* as specified in Chapter 10 and the *International Building Code*.

M1306.2.5 (308.4.2.3) Chimney connector passthroughs. The *clearance* reduction methods specified in Table M1306.2 shall not be utilized to reduce the *clearances* required for *chimney* connector pass-throughs as specified in Table M1803.3.5 and Figure M138063.43.5.



~~FIGURE M1206.2.5~~
~~CHIMNEY CONNECTOR SYSTEMS~~



~~FIGURE M1306.2.3—continued
CHIMNEY CONNECTOR SYSTEMS~~

M1306.2.6 (308.4.2.4) Masonry fireplaces. The *clearance* reduction methods specified in Table M1306.2 shall not be utilized to reduce the *clearances* required for masonry fireplaces as specified in Chapter 10 and the *International Building Code*.

M1307.1 (304.1) General. Installation of *appliances* shall conform to the conditions of their *listing* and *label* and the manufacturer's instructions. The manufacturer's operating and installation instructions shall remain attached to the *appliance*. *Equipment* and *appliances* shall be installed as required by the terms of their approval, in accordance with the conditions of the listing, the manufacturer's installation instructions and this code. Manufacturer's installation instructions shall be available on the job site at the time of inspection.

M1307.2 Anchorage of appliances. *Appliances* designed to be fixed in position shall be fastened or anchored in an *approved* manner. In *Seismic Design Categories* D₀, D₁ and D₂, and in townhouses in *Seismic Design Category* C, water heaters and thermal storage units shall be anchored or strapped to resist horizontal displacement caused by earthquake motion in accordance with one of the following:

1. Anchorage and strapping shall be designed to resist a horizontal force equal to one-third of the operating weight of the water heater storage tank, acting in any horizontal direction. Strapping shall be at points within the upper one-third and lower one-third of the *appliance's* vertical dimensions. At the lower point, the strapping shall maintain a minimum distance of 4 inches (102 mm) above the controls.
2. The anchorage strapping shall be in accordance with the appliance manufacturer's recommendations.

~~Deleted.~~

M1307.3 (304.3) Elevation of ignition source. *Appliances* having an *ignition source* shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in garages. For the purpose of this section,

rooms or spaces that are not part of the *living space* of a *dwelling unit* and that communicate with a private garage through openings shall be considered to be part of the garage.

Exception: Elevation of the *ignition source* is not required for *appliances* that are *listed* as flammable-vapor-ignition resistant.

M1307.3.1 Protection from impact. *Appliances* shall not be installed in a location subject to vehicle damage except where protected by *approved barriers*.

M1307.3.2 Private garages. *Appliances* located in private garages and carports shall be installed with a minimum clearance of 6 feet (1829 mm) above the floor. *Appliances* located out of the normal path of travel are not required to be protected.

Exception: The requirements of this section shall not apply where the *appliances* are protected from motor vehicle impact and installed in accordance with Section M1307.3.

M1307.4 (304.5) Hydrogen-generating and refueling operations. *Ventilation* shall be required in accordance with Section M1307.4.1, M1307.4.2 or M1307.4.3 in private garages that contain hydrogen-generating *appliances* or refueling systems. For the purpose of this section, rooms or spaces that are not part of the *living space* of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage. *As per Section 703.2.1 of the International Fuel Gas Code, flammable gas cylinders in occupancies regulated by the International Residential Code shall not exceed 250 cubic feet (7.1 m³) at normal temperature and pressure (NTP).*

M1307.5 Electrical appliances. Electrical *appliances* shall be installed in accordance with Chapters 14, 15, 19, and 20 and 34 through 43 and the *North Carolina Electrical Code*.

M1307.7 Prohibited support. Gypsum board shall not be used as a support base under an *appliance*.

M1308.1 (302.3, 302.5) Drilling and notching. Wood-framed structural members shall be drilled, notched or altered in accordance with the provisions of Sections R502.8, R602.6, R602.6.1 and R802.7. Holes in load-bearing members of cold-formed steel *light-frame construction* shall **not** be permitted *unless prescribed by a registered design professional* only in accordance with Sections R505.2.6, R603.2.6 and R804.2.6. *In accordance with the provisions of Sections R505.3.5, R603.3.4 and R804.3.3, cutting and notching of flanges and lips of load-bearing members of cold-formed steel light frame construction shall not be permitted unless prescribed by a registered design professional.* Structural insulated panels (SIPs) shall be drilled and notched or altered in accordance with the provisions of Section R610.7.

M1308.2 (305.5) Protection against physical damage. Where piping will be concealed within *light-frame construction* assemblies, the piping shall be protected against penetration by fasteners in accordance with Sections M1308.2.1 through M1308.2.3.

Exception: Cast-iron piping and galvanized steel piping shall not be required to be protected.

M1308.2.1 Piping through bored holes or notches. Where *piping* is installed through holes or notches in framing members and is located less than 1½ inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the pipe shall be protected by shield plates that cover the width of the pipe and the framing member and that extend 2 inches (51 mm) to each side of the framing member. Where the framing member that the piping passes through is a bottom plate, bottom track, top plate or top track, the shield plates shall cover the framing member and extend 2 inches (51 mm) above the bottom framing member(s) and 2 inches (51 mm) below the top framing member(s).

M1308.2.2 Piping in other locations. Where piping is located within a framing member (*i.e. steel studs*) and is less than 1½ inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the piping shall be protected by shield plates that cover the width and length of the piping. Where piping is located outside of a framing member and is located less than 1½ inches (38 mm) from the nearest edge of the face of the framing member to which the membrane will be attached, the piping shall be protected by shield plates that cover the width and length of the piping.

M1308.3 (305.5) Piping Support. *Piping systems shall be supported in accordance with Section M2101.9. Hanger spacing intervals for piping supports shall be per Table M2101.9.*

M1308.4 Pipe and duct penetrations. Openings for pipe and duct penetrations in walls, floors or ceilings shall be larger than the penetrating pipe or duct. Openings through concrete or masonry building elements shall be sleeved. The annular space surrounding pipe and duct penetrations shall be protected in an *approved* manner in accordance with this code.

User notes:

— **About this chapter:** Chapter 14 addresses the indoor environmental control systems and appliances typically found in dwelling units. Coverage includes general requirements for equipment and appliance sizing, condensate disposal, access and support, and specific coverage for more than a dozen different types of space conditioning equipment and appliances common to dwelling units.

— **Code development reminder:** Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical i.e., (312.1) and Residential i.e., (R1004.1) Codes.

M1401.2 Access. Heating and cooling *equipment* and *appliances* shall be located with respect to building construction and other *equipment* and *appliances* to permit maintenance, servicing and replacement. Clearances shall be maintained to permit cleaning of heating and cooling surfaces; replacement of filters, blowers, motors, controls and vent connections; lubrication of moving parts; and adjustments.

Exception: Access shall not be required for ducts, piping, or other components *approved* for concealment.

M1401.3 (312.1) Equipment and appliance sizing. Heating and cooling *equipment* and *appliances* shall be sized in accordance with ACCA Manual S or other *approved* sizing methodologies based on building loads calculated in accordance with ACCA Manual J or other *approved* heating and cooling calculation methodologies.

Exception: Heating and cooling *equipment* and *appliance* sizing shall not be limited to the capacities determined in accordance with ACCA Manual S where either of the following conditions applies:

1. The specified *equipment* or *appliance* utilizes multistage technology or variable refrigerant flow technology and the loads calculated in accordance with the *approved* heating and cooling calculation methodology are within the range of the manufacturer's published capacities for that *equipment* or *appliance*.
2. The specified *equipment* or *appliance* manufacturer's published capacities cannot satisfy both the total and sensible heat gains calculated in accordance with the *approved* heating and cooling calculation methodology and the next larger standard size unit is specified.

For permitting, inspections, certificate of compliance or certificate of occupancy, verification of *Calculations for HVAC Systems—ACCA Manual D, ACCA Manual J, ACCA Manual S load and sizing* calculation submittals and review shall not be required.

M1401.4 (303.5) Outdoor installations. *Equipment* and *appliances* installed outdoors shall be *listed* and *labeled* for outdoor installation. Supports and foundations shall prevent excessive vibration, settlement or movement of the *equipment*. Supports and foundations shall be in accordance with Section M1305.1.3.1.

M1401.5 Flood hazard. In flood hazard areas as established by Table R301.2, heating and cooling *equipment* and *appliances* shall be located or installed in accordance with Section R322.1.6.

M1402.1 (918.1) General. Oil-fired central furnaces shall conform to ANSI/UL 727. Electric furnaces shall conform to UL 1995 or UL/CSA/ANCE 60335-2-40. Solid fuel furnaces shall be tested in accordance with UL 391.

M1402.4 (918.3) Dampers. Volume dampers shall not be placed in the air inlet to a furnace in a manner that will reduce the required air to the furnace.

M1402.5 (918.4) Circulating air ducts for forced-air warm-air furnaces. Circulating air for fuel-burning, forced air-type, warm-air furnaces shall be conducted into the blower housing from outside the furnace enclosure by continuous air-tight ducts.

M1402.6 (918.5) Outdoor and return air openings. Outdoor intake openings shall be located in accordance with Section M1602.1. Return air openings shall be located in accordance with Section M1602.2.

M1402.7 (918.6) Outdoor opening protection. Outdoor air intake openings shall be protected in accordance with Section R303.6.

M1402.8 (918.7) Refrigeration coils in warm-air furnaces. When a cooling coil is located in the supply plenum of a warm-air furnace, the furnace blower shall be rated at not less than 0.5-inch water column (124 Pa) static pressure unless the furnace is *listed* and *labeled* for use with a cooling coil. Cooling coils shall not be located upstream from *heat exchangers* unless *listed* and *labeled* for such use. Conversion of existing furnaces for use with cooling coils shall be permitted provided the furnace will operate within the temperature rise specified for the furnace.

M1403.1 (918.2) Heat pumps. Electric heat pumps shall be *listed* and *labeled* in accordance with UL 1995 or UL/CSA/ANCE 60335-2-40.

M1405.1 (929.1) General. Electric baseboard convectors shall be installed in accordance with the manufacturer's instructions and Chapters 34 through 43 *the North Carolina Electrical Code*. Electric baseboard heaters shall be *listed* and *labeled* in accordance with UL 1042.

M1406.1 (927) General. Electric radiant heating systems shall be installed in accordance with the manufacturer's instructions and Chapters 34 through 43 *the North Carolina Electrical Code* and shall be *listed* for the application.

M1406.2 Clearances. Clearances for radiant heating panels or elements to any wiring, outlet boxes and junction boxes used for installing electrical devices or mounting luminaires shall comply with Chapters 34 through 43 *the North Carolina Electrical Code*.

M1407.1 (930.1) General. Electric duct heaters shall be installed in accordance with the manufacturer's instructions and Chapters 34 through 43 *the North Carolina Electrical Code*. Electric duct heaters shall comply with UL 1996.

M1407.2 (930.2) Installation. Electric duct heaters shall be installed so that they will not create a fire hazard. Class 1 ducts, duct coverings and linings shall be interrupted at each heater to provide the clearances specified in the manufacturer's installation instructions. Such interruptions are not required for duct heaters *listed* and *labeled* for zero clearance to *combustible materials*. Insulation installed in the immediate area of each heater shall be classified for the maximum temperature produced on the duct surface.

M1407.3 (930.3) Installation with heat pumps and air conditioners. Duct heaters located within 4 feet (1219 mm) of a heat pump or air conditioner shall be *listed* and *labeled* for such installations. The heat pump or air conditioner shall additionally be *listed* and *labeled* for such duct heater installations.

M1407.4 (930.4) Access. Duct heaters shall be *located to allow access* for servicing, and clearance shall be maintained to permit adjustment, servicing and replacement of controls and heating elements.

M1407.5 (930.5) Fan interlock. The fan circuit shall be provided with an interlock to prevent heater operation when the fan is not operating.

M1408.1 (910.1) General. Oil-fired vented *floor furnaces* shall comply with UL 729 and shall be installed in accordance with their *listing*, the manufacturer's instructions and the requirements of this code.

M1408.2 (910.4) Clearances. Vented *floor furnaces* shall be installed in accordance with their listing and the manufacturer's instructions.

M1408.3 (910.2) Location. Location of *floor furnaces* shall conform to the following requirements:

1. *Floor* registers of *floor furnaces* shall be installed not less than 6 inches (152 mm) from a wall.

2. Wall registers of **floor furnaces** shall be installed not less than 6 inches (152 mm) from the adjoining wall at inside corners.
3. The furnace register shall be located not less than 12 inches (305 mm) from doors in any position, draperies or similar combustible objects.
4. The furnace register shall be located not less than 5 feet (1524 mm) below any projecting **combustible materials**.
5. The **floor furnace** burner assembly shall not project into an occupied under-floor area.
6. The **floor furnaces** shall not be installed in concrete floor construction built on grade.
7. The **floor furnaces** shall not be installed where a door can swing within 12 inches (305 mm) of the grille opening.

M1408.4 Access. An opening in the foundation not less than 18 inches by 24 inches (457 mm by 610 mm), or a trap door not less than 22 inches by 30 inches (559 mm by 762 mm) shall be provided for access to a **floor furnace**. The opening and passageway shall be large enough to allow replacement of any part of the *equipment*.

M1408.5 (910.4) Installation. **Floor furnace** installations shall conform to the following requirements:

1. Thermostats controlling **floor furnaces** shall be located in the room in which the register of the **floor furnace** is located.
2. **Floor furnaces** shall be supported independently of the furnace floor register.
3. **Floor furnaces** shall be installed not closer than 6 inches (152 mm) to the ground. The minimum clearance shall be 2 inches (51 mm), where the lower 6 inches (152 mm) of the furnace is sealed to prevent water entry.
4. Where excavation is required for a **floor furnace** installation, the excavation shall extend 30 inches (762 mm) beyond the control side of the **floor furnace** and 12 inches (305 mm) beyond the remaining sides. Excavations shall slope outward from the perimeter of the base of the excavation to the surrounding *grade* at an angle not exceeding 45 degrees (0.79 rad) from horizontal.
5. **Floor furnaces** shall not be supported from the ground.

M1409.1 (909.1) General. Oil-fired vented wall furnaces shall comply with UL 730 and shall be installed in accordance with their *listing*, the manufacturer's instructions and the requirements of this code.

M1409.2 (909.2) Location. The location of vented wall furnaces shall conform to the following requirements:

1. Vented wall furnaces shall be located where they will not cause a fire hazard to walls, floors, combustible furnishings or doors. Vented wall furnaces installed between bathrooms and adjoining rooms shall not circulate air from bathrooms to other parts of the building.
2. Vented wall furnaces shall not be located where a door can swing within 12 inches (305 mm) of the furnace air inlet or outlet measured at right angles to the opening. Doorstops or door closers shall not be installed to obtain this clearance.

M1409.3 (909.4) Installation. Vented wall furnace installations shall conform to the following requirements:

1. Required wall thicknesses shall be in accordance with the manufacturer's installation instructions.
2. Ducts shall not be attached to a wall furnace. Casing extensions or boots shall be installed only where listed as part of a *listed and labeled appliance*.
3. A manual shutoff valve shall be installed ahead of all controls.

M1409.4 (909.6) Access. Vented wall furnaces shall be provided with access for cleaning of heating surfaces; removal of burners; replacement of sections, motors, controls, filters and other working parts; and for adjustments and lubrication of parts requiring such attention. Panels, grilles and access doors that must be removed for normal servicing operations shall not be attached to the building construction.

M1410.1 (904.1, 922) General. Vented room heaters shall be tested in accordance with ASTM E1509 for pellet-fuel burning, UL 896 for oil-fired or UL 1482 for solid fuel-fired and installed in accordance with their *listing*, the manufacturer's installation instructions and the requirements of this code.

M1410.2 Floor mounting. Room heaters shall be installed on noncombustible floors or *approved* assemblies constructed of *noncombustible materials* that extend not less than 18 inches (457 mm) beyond the *appliance* on all sides.

Exceptions:

1. *Listed* room heaters shall be installed on noncombustible floors, assemblies constructed of *noncombustible materials* or floor protectors *listed* and *labeled* in accordance with UL 1618. The materials and dimensions shall be in accordance with the *appliance* manufacturer's instructions.
2. Room heaters *listed* for installation on combustible floors without floor protection shall be installed in accordance with the *appliance* manufacturer's instructions.

M1410.3 (905.3) Hearth extensions. Hearth extensions for fireplace stoves shall be installed in accordance with the listing of the fireplace stove. The hearth extension shall be readily distinguishable from the surrounding floor area. *Listed* and *labeled* hearth extensions shall comply with UL 1618.

M1411.2 Refrigeration coils in warm-air furnaces. Where a cooling coil is located in the supply plenum of a warm-air furnace, the furnace blower shall be rated at not less than 0.5 inch water column (124 Pa) static pressure unless the furnace is *listed* and *labeled* for use with a cooling coil. Cooling coils shall not be located upstream from heat exchangers unless *listed* and *labeled* for such use. Conversion of existing furnaces for use with cooling coils shall be permitted provided that the furnace will operate within the temperature rise specified for the furnace. See Section M1402.8.

M1411.3 (307.2) Condensate disposal. Condensate from cooling coils, *condensing furnaces* and evaporators shall be conveyed from the drain pan outlet to an *approved* place of disposal. Such piping shall maintain a minimum horizontal slope in the direction of discharge of not less than $\frac{1}{8}$ unit vertical in 12 units horizontal (1-percent slope). Where pumps are used, they shall be installed with a factory-equipped auxiliary high-level switch that shall shut off equipment served upon activation of the auxiliary high-level switch. Where damage to any building components will occur as a result of overflow from the pump, the pump shall also be located in the auxiliary drain pan or in a separate drain pan equipped with a separate drain line or water level detection device. Condensate shall not discharge into a street, alley or other *area* where it would cause a nuisance.

M1411.3.1 Auxiliary and secondary drain systems. In addition to the requirements of Section M1411.3, a secondary drain or auxiliary drain pan shall be required for each cooling or evaporator coil where damage to any building components will occur as a result of overflow from the *equipment* drain pan or stoppage in the condensate drain piping. Such piping shall maintain a minimum horizontal slope in the direction of discharge of not less than $\frac{1}{8}$ unit vertical in 12 units horizontal (1-percent slope). Drain piping shall be not less than $\frac{3}{4}$ -inch (19 mm) nominal pipe size. One of the following methods shall be used:

1. An auxiliary drain pan with a separate drain shall be installed under the coils on which condensation will occur. The auxiliary pan drain shall discharge to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. The pan shall have a minimum depth of 1.5 inches (38 mm), shall be not less than 3 inches (76 mm) larger than the unit or the coil dimensions in width and length and shall be constructed of corrosion-resistant material. Galvanized sheet steel pans shall have a minimum thickness of not less than 0.0236-inch (0.6010 mm) (No. 24 Gage). Nonmetallic pans shall have a minimum thickness of not less than 0.0625 inch (1.6 mm).

a. Appliances with primary condensate pans above appliance components. Cooling coils mounted above the air handler or furnace shall have a secondary drain piped to auxiliary pan under the air handler to avoid condensate migrating through appliance components before reaching the auxiliary drain pan.

To prevent condensate migrating through the *appliance*, whenever cooling coils are located above the auxiliary drain pan, a secondary drain shall be piped from the overflow drain of the *equipment*-supplied drain pan to the auxiliary drain pan.

2. A separate overflow drain line shall be connected to the drain pan installed with the *equipment*. This overflow drain shall discharge to a conspicuous point of disposal to alert occupants in the event of a stoppage of the primary drain. The overflow drain line shall connect to the drain pan at a higher level than the primary drain connection.
3. An auxiliary drain pan without a separate drain line shall be installed under the coils on which condensation will occur. This pan shall be equipped with a water level detection device conforming to UL 508 that will shut off the *equipment* served prior to overflow of the pan. The pan shall be equipped with a fitting to allow for drainage. The auxiliary drain pan shall be constructed in accordance with Item 1 of this section.
4. A water level detection device conforming to UL 508 shall be installed that will shut off the *equipment* served in the event that the primary drain is blocked. The device shall be installed in the primary drain line, upstream of the primary drain line trap, the overflow drain line or the *equipment*-supplied drain pan, located at a point higher than the primary drain line connection and below the overflow rim of such pan.

Exception: Fuel-fired *appliances* that automatically shut down operation in the event of a stoppage in the condensate drainage system.

M1411.3.1.1 (307.2.3.1) Water-level monitoring devices. On down-flow units and other coils that do not have secondary drain or provisions to install a secondary or auxiliary drain pan, a water-level monitoring device shall be installed inside the primary drain pan. This device shall shut off the *equipment* served in the event that the primary drain becomes restricted. Devices shall not be installed in the drain line.

M1411.3.1.2 Appliance, equipment and insulation in pans. Where *appliances*, *equipment* or insulation are subject to water damage when auxiliary drain pans fill, that portion of the *appliance*, *equipment* and insulation shall be installed above the rim of the pan. Supports located inside of the pan to support the *appliance* or *equipment* shall be water resistant and *approved*.

M1411.3.2 (307.2.2) Drain pipe materials and sizes. Components of the condensate disposal system shall be ABS, cast iron, copper, cross-linked polyethylene, CPVC, galvanized steel, PE-RT, polyethylene, polypropylene or PVC pipe or tubing. Components shall be selected for the pressure and temperature rating of the installation. Joints and connections shall be made in accordance with the applicable provisions of Chapter 30. Condensate waste and drain line size shall be not less than 3/4-inch (19 mm) nominal diameter from the drain pan connection to the place of condensate disposal. Where the drain pipes from more than one unit are manifolded together for condensate drainage, the pipe or tubing shall be sized in accordance with an *approved* method. Hanger spacing intervals for piping supports shall be per Table M2101.9. Condensate piping shall be insulated to an R-value of not less than R-3.

Provisions shall be made to prevent the formation of condensation on the exterior of primary condensate drain piping if condensate dripping off the pipe could cause damage to any building component.

M1411.3.4 (307.2.3.2) Appliances, equipment and insulation in pans. Where *appliances*, *equipment* or insulation are subject to water damage when auxiliary drain pans fill, those portions of the *appliances*, *equipment* and insulation shall be installed above the flood level rim of the pan. Supports located inside of the pan to support the *appliance* or *equipment* shall be water resistant and *approved*.

M1411.3.5 (307.2.4) Traps. Condensate drains shall be trapped as required by the *equipment* or *appliance* manufacturer.

M1411.3.5.1 (307.2.4.1) Ductless mini-split system traps. Ductless mini-split *equipment* that produces condensate shall be provided with an inline check valve located in the drain line, or a trap.

M1411.4 (307.3) Condensate pumps. Condensate pumps located in uninhabitable spaces, such as attics and crawl spaces, shall be connected to the *appliance* or *equipment* served such that when the pump fails, the *appliance* or *equipment* will be prevented from operating. Pumps shall be installed in accordance with the manufacturer's instructions.

M1411.6 Insulation of refrigerant piping. Piping and fittings for refrigerant vapor (suction) lines shall be insulated with insulation having a thermal resistivity of not less than R-3 and having external surface permeance not exceeding 0.05 perm [2.87 ng/(s × m² × Pa)] when tested in accordance with ASTM E96. Insulation shall be protected in accordance with Section N1103.3.1.

M1411.6.1 Refrigerant line insulation protection. Refrigerant piping insulation shall be protected in accordance with Section N1103.4.1.

M1411.7 Location and protection of refrigerant piping. Refrigerant piping installed within 1½ inches (38 mm) of the underside of *roof decks* shall be protected from damage caused by nails and other fasteners. ~~Deleted.~~

M1411.8 Support of refrigerant piping. Refrigerant piping and tubing shall be securely fastened to a permanent support within 6 feet (1829 mm) of the condensing unit.

M1411.9 Locking access port caps. Refrigerant circuit access ports located outdoors shall be fitted with locking-type tamper-resistant caps or shall be otherwise secured to prevent unauthorized access. ~~Deleted.~~

M1411.10 Pipe penetrations. Openings for pipe penetrations in walls, floors or 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 sealed and protected in an *approved* manner in accordance with this code.

~~Deleted.~~

M1412.1 Approval of equipment. Absorption systems shall be installed in accordance with the manufacturer's instructions. Absorption *equipment* shall comply with UL 1995 or UL/CSA/ANCE 60335-2-40.

M1412.2 Condensate disposal. Condensate from the cooling coil shall be disposed of as provided in Section M1411.3.

M1412.3 Insulation of piping. Refrigerant piping, brine piping and fittings within a building shall be insulated to prevent condensation from forming on piping.

M1412.4 Pressure-relief protection. Absorption systems shall be protected by a pressure-relief device. Discharge from the pressure-relief device shall be located where it will not create a hazard to persons or property.

~~Deleted.~~

M1413.1 General. Evaporative cooling *equipment* and *appliances* shall comply with UL 1995 or UL/CSA/ANCE 60335-2-40 and shall be installed:

1. In accordance with the manufacturer's instructions.
2. On level platforms in accordance with Section M1305.1.3.1.
3. So that openings in exterior walls are flashed in accordance with Section R703.4.
4. So as to protect the potable water supply in accordance with Section P2902.
5. So that air intake opening locations are in accordance with Section R303.5.1.

M1414.1 (905.1) General. Fireplace stoves shall be *listed*, *labeled* and installed in accordance with the terms of the listing. Fireplace stoves shall be tested in accordance with UL 737. Fireplace inserts intended for installation in fireplaces shall be *listed* and *labeled* in accordance with the requirements of UL 1482 and shall be installed in accordance with the manufacturer's instructions.

M1414.2 (905.2) Connection to fireplace. The connection of solid fuel *appliances* to *chimney* flues serving fireplaces shall comply with Sections M1803.4 and M1805.3.1.

M1414.2 M1414.3 (905.3) Hearth extensions. Hearth extensions for fireplace stoves shall be installed in accordance with the *listing* of the fireplace stove. The supporting structure for a hearth extension for a fireplace stove shall be at the same level as the supporting structure for the fireplace unit. The hearth extension shall be readily distinguishable from the surrounding floor area. Listed and labeled hearth extensions shall comply with UL 1618.

M1415.1 General. *Masonry heaters* shall be constructed in accordance with Section R1002.

M1416.1 (R1004.1) General. Factory-built fireplaces shall be *listed* and *labeled* and shall be installed in accordance with the conditions of the *listing*. Factory-built fireplaces shall be tested in accordance with UL 127.

M1416.2 (R1004.2) Hearth extensions. Hearth extensions of *approved* factory-built fireplaces shall be installed in accordance with the *listing* of the fireplace. The hearth extension shall be readily distinguishable from the surrounding floor area. *Listed* and *labeled* hearth extensions shall comply with UL 1618.

M1416.3 (R1004.3) Decorative shrouds. Decorative shrouds shall not be installed at the termination of chimneys for factory-built fireplaces ~~systems~~ *except where the shrouds are listed and labeled for use with the specific factory-built fireplace system* and installed in accordance with the manufacturer's instructions.

M1416.4 (R1004.4) Unvented gas log heaters. An unvented gas log heater shall not be installed in a factory-built fireplace unless the fireplace system has been specifically tested, *listed* and *labeled* for such use in accordance with UL 127.

M1416.5 (R1004.5) Gasketed fireplace doors. A gasketed fireplace door shall not be installed on a factory-built fireplace except where the fireplace system has been specifically tested, *listed* and *labeled* for such use in accordance with UL 127.

User notes:

About this chapter: Chapter 15 is specific to exhaust systems related to clothes dryers, domestic cooking, toilet rooms, bathrooms and whole-house ventilation systems. Included are requirements for exhaust discharge locations, protection of exhaust ducts from damage, exhaust duct construction, duct length limits, and exhaust termination clearances. This chapter contains prohibitions for exhaust recirculation and discharge locations and addresses the design of whole-house ventilation systems required by Chapter 3.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M1501.1 (501.3) Outdoor discharge. The air removed by every mechanical exhaust system shall be discharged to the outdoors in accordance with Section M1504.3. Air shall not be exhausted into an attic, soffit, ridge vent or *crawl space*. ~~Exhaust shall not be directed onto walkways, balconies, decks, breezeways, covered walkways and similar horizontal projections.~~

Exceptions:

1. Whole-house *ventilation*-type attic fans that discharge into the **attic** space of *dwelling units* having private *attics* shall be permitted.
2. Where installed in accordance with the manufacturer's instructions and where mechanical or *natural ventilation* is otherwise provided in accordance with Sections M1505 or R303.1, *listed* and *labeled* domestic ductless range hoods shall not be required to discharge to the outdoors.

M1502.1.1 (504.6) Makeup air. Where ~~a closet~~ an enclosed space is less than 70 square feet and is designed for the installation of a clothes dryer, an opening having an area of not less than 100 square inches (0.0645 m²) shall be provided in the ~~closet~~ enclosure or *makeup air* shall be provided by other *approved* means.

M1502.3 (504.8.7) Duct termination. Exhaust ducts shall terminate on the outside of the building. Exhaust duct terminations shall be in accordance with the dryer manufacturer's installation instructions. If the manufacturer's instructions do not specify a termination location, the exhaust duct shall terminate not less than 3 feet (914 mm) in any direction from openings into buildings, including openings in ventilated soffits. ~~The exhaust duct terminations shall not discharge onto walkways, balconies, decks, breezeways, covered walkways and similar horizontal projections.~~ Exhaust duct terminations shall be equipped with a backdraft damper. Screens shall not be installed at the duct termination or *weather cap* outlet. ~~An e~~Exhaust ducts shall terminate not less than 12 inches (305 mm) above finished grade.

Exception: Where the duct termination is less than 12 inches (305 mm) above finished grade, an areaway shall be provided with a cross-sectional area not less than 200 square inches (1290 cm²). The bottom of the duct termination shall be no less than 12 inches (305 mm) above the areaway bottom.

M1502.3.1 Exhaust termination outlet and passageway size. The passageway of dryer exhaust duct terminals shall be undiminished in size and shall provide an open area of not less than 12.5 square inches (8065 mm²).

M1502.4 (504.8) Dryer exhaust ducts. Dryer exhaust ducts shall conform to the requirements of Sections M1502.4.1 through M1502.4.8.

M1502.4.1 Material and size. Exhaust ducts shall have a smooth interior finish and shall be constructed of metal not less than 0.0157 inch (0.3950 mm) in thickness (No. 28 gage) (No. 28 gage for steel, No. 26 gage for aluminum). With the exception of the transition duct, flexible ducts are prohibited. The duct shall be 4 inches (102 mm) nominal in diameter.

M1502.4.2 Duct installation. Exhaust ducts shall be supported at intervals not to exceed 124 feet (36581219 mm) and shall be secured in place. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow. Exhaust duct joints shall be sealed in accordance with Section M1601.4.1 and shall be mechanically fastened. ~~Ducts shall not be joined with screws or similar fasteners that protrude more than 1/8 inch (3.2 mm) into the inside of the duct.~~ Ducts shall not be joined with screws or similar fasteners that protrude into the inside of the duct. ~~Ducts shall be sealed in accordance with Section M1601.4.1.~~ Ducts shall be mechanically fastened by one of the following methods:

- a. Nonmetallic mechanical fasteners (tie-straps) shall be listed to UL 181B.
- b. Metal band duct clamps are not required to be listed.

Where dryer exhaust ducts are enclosed in wall or ceiling cavities, such cavities shall allow the installation of the duct without deformation.

M1502.4.3 (504.8.3) Transition duct. Transition ducts used to connect the dryer to the exhaust *duct system* shall be a single length that is *listed* and *labeled* in accordance with UL 2158A. Transition ducts shall be not greater than 8 feet (2438 mm) in length. Transition ducts shall not be concealed within construction and must remain entirely within the room where the *appliance* is located.

M1502.4.4 (504.8.4.3) Dryer exhaust duct power ventilators. Domestic dryer exhaust duct power ventilators shall conform to UL 705 for use in dryer exhaust duct systems. The dryer exhaust duct power ventilator shall be installed in accordance with the manufacturer's instructions.

M1502.4.5 Booster fans prohibited. Domestic booster fans shall not be installed in dryer exhaust systems.

M1502.4.6 (504.8.4) Duct length. The maximum allowable exhaust duct length shall be determined by one of the methods specified in Sections M1502.4.6.1 through M1502.4.6.3.

M1502.4.6.1 Specified length. The maximum length of the exhaust duct shall be 35 feet (10 668 mm) from the connection to the transition duct from the dryer to the outlet terminal. Where fittings are used, the maximum length of the exhaust duct shall be reduced in accordance with Table M1502.4.6.1. The maximum length of the exhaust duct does not include the transition duct.

M1502.4.6.2 Manufacturer's instructions. The size and maximum length of the exhaust duct shall be determined by the dryer manufacturer's installation instructions. The code official shall be provided with a copy of the installation instructions for the make and model of the dryer at the concealment inspection. In the absence of fitting equivalent length calculations from the clothes dryer manufacturer, Table M1502.4.6.1 shall be used.

M1502.4.6.3 Dryer exhaust duct power ventilator. The maximum length of the exhaust duct shall be determined in accordance with the manufacturer's instructions for the dryer exhaust duct power ventilator.

M1502.4.7 Length identification. Where the exhaust duct equivalent length exceeds 35 feet (10 668 mm), the equivalent length of the exhaust duct shall be identified on a permanent *label* or tag. The *label* or tag shall be located within 6 feet (1829 mm) of the exhaust duct connection.

1. Labels shall be permanently stenciled, laminated, or commercially available plastic or metal tags.
2. Labels shall state, at a minimum (fill in the blank):

Caution: Equivalent length of _____ feet including _____ 45 deg. elbows and _____ 90 deg. elbows. Any installed dryer must be equipped with an exhaust system that meets or exceeds this equivalent length requirement.

3. Labels can be attached to wall or vent receptor.

M1502.4.8 (504.8.5) Exhaust duct required. Where space for a clothes dryer is provided, an exhaust *duct system* shall be installed. Where the clothes dryer is not installed at the time of occupancy the exhaust duct shall be capped or plugged in the space in which it originates and identified and marked "future use."

Exception: Where a *listed* condensing clothes dryer is installed prior to occupancy of the structure.

M1502.5 (504.7) Protection required. Protective shield plates shall be placed where nails or screws from finish or other work are likely to penetrate the clothes dryer exhaust duct. Shield plates shall be placed on the finished face of framing members where there is less than 1 1/4 inches (32 mm) between the duct and the finished face of the framing member. Protective shield plates shall be constructed of steel, shall have a minimum thickness of 0.062-inch (1.6 mm) and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.

SECTION M1503
DOMESTIC COOKING EXHAUST EQUIPMENT

M1503.1 (505.1) General. Domestic cooking exhaust equipment shall comply with the requirements of this section.

M1503.2 Domestic cooking exhaust. Where domestic cooking exhaust equipment is provided, it shall comply with one of the following:

1. The fan for overhead range hoods and downdraft exhaust equipment not integral with the cooking *appliance* shall be *listed* and *labeled* in accordance with UL 507.
2. Overhead range hoods and downdraft exhaust equipment with integral fans shall comply with UL 507.
3. Domestic cooking *appliances* with integral downdraft exhaust equipment shall be *listed* and *labeled* in accordance with ANSI Z21.1 or UL 858.
4. Microwave ovens with integral exhaust for installation over the cooking surface shall be *listed* and *labeled* in accordance with UL 923.

M1503.2.1 Open-top broiler exhaust. Domestic open-top broiler units shall be provided with a metal exhaust hood having a thickness of not less than 0.0157 inch (0.3950 mm) (No. 28 gage). Such hoods shall be installed with a clearance of not less than 1/4 inch (6.4 mm) between the hood and the underside of *combustible material* and cabinets. A clearance of not less than 24 inches (610 mm) shall be maintained between the cooking surface and *combustible material* and cabinets. The hood width shall be not less than the width of the broiler unit and shall extend over the entire unit.

Exception: Broiler units that incorporate an integral exhaust system, and that are *listed* and *labeled* for use without an exhaust hood, shall not be required to have an exhaust hood.

M1503.3 Exhaust discharge. Domestic cooking exhaust equipment shall discharge to the outdoors through a duct. The duct shall have a smooth interior surface, shall be airtight, shall be equipped with a backdraft damper and shall be independent of all other exhaust systems. Ducts serving domestic cooking exhaust equipment shall not terminate in an attic or *crawl space* or areas inside the building.

Exception: Where installed in accordance with the manufacturer's instructions, and where mechanical or natural *ventilation* is otherwise provided, *listed* and *labeled* ductless range hoods shall not be required to discharge to the outdoors.

M1503.4 (505.1) Duct material. Ducts serving domestic cooking exhaust equipment shall be constructed of galvanized steel, stainless steel or copper.

Exception: Ducts for domestic kitchen cooking *appliances* equipped with down-draft exhaust systems shall be permitted to be constructed of schedule 40 PVC pipe and fittings provided that the installation complies with all of the following:

1. The duct is installed under a concrete slab poured on grade.
2. The underfloor trench in which the duct is installed is completely backfilled with sand or gravel.
3. The PVC duct extends not more than 1 inch (25 mm) above the indoor concrete floor surface.
4. The PVC duct extends not more than 1 inch (25 mm) above grade *outside of the building*.
5. The PVC ducts are solvent cemented.

M1503.5 Kitchen exhaust rates. Where domestic kitchen cooking *appliances* are equipped with ducted range hoods or down-draft exhaust systems, the fans shall be sized in accordance with Section M1505.4.4. ~~Deleted.~~

M1503.6 (505.2) Makeup air required. Where one or more gas, liquid or solid fuel burning *appliance* that is neither direct vent nor uses a mechanical draft venting system is located within a dwelling unit's air barrier, each exhaust system capable of exhausting in excess of 400 cubic feet per minute (0.19 m³/s) shall be mechanically or passively provided with makeup air at a rate approximately equal to the exhaust air rate. Such makeup air systems shall be equipped with not fewer than one damper complying with Section M1503.6.2.

Exception: Makeup air is not required for exhaust systems installed for the exclusive purpose of space cooling and intended to be operated only when windows or other air inlets are open.

Exhaust hood systems capable of exhausting in excess of 400 cubic feet per minute (0.19 m³/s) shall be provided with makeup air at a rate approximately equal to the exhaust air rate that is in excess of 400 cubic feet per minute (0.19 m³/s). Such makeup air systems shall be equipped with a means of closure and shall be automatically controlled to

~~start and operate simultaneously with the exhaust system. Dampers shall be accessible for inspection, service, repair and replacement without removing permanent construction or any other ducts not connected to the damper being inspected, serviced, repaired or replaced.~~

~~**Exception:** Where all appliances in the house are direct vent, power vent, unvented, or electric, makeup air shall be provided where exhaust fans are capable of exhausting more than 600 cubic feet per minute (0.28 m³/s). Exhaust hood systems capable of exhausting more than 600 cubic feet per minute (0.28 m³/s) shall be provided with makeup air at a rate approximately equal to the exhaust air rate that is in excess of 600 cubic feet per minute (0.28 m³/s).~~

M1503.6.1 Location. Kitchen exhaust makeup air shall be discharged into the same room in which the exhaust system is located or into rooms or *duct systems* that communicate through one or more permanent openings with the room in which such exhaust system is located. Such permanent openings shall have a net cross-sectional area not less than the required area of the makeup air supply openings.

M1503.6.2 Makeup air dampers. Where makeup air is required by Section M1503.6, makeup air dampers shall comply with this section. Each damper shall be a gravity damper or an electrically operated damper that automatically opens when the exhaust system operates. Dampers shall be located to allow access for inspection, service, repair and replacement without removing permanent construction or any other ducts not connected to the damper being inspected, serviced, repaired or replaced. Gravity or barometric dampers shall not be used in passive makeup air systems except where the dampers are rated to provide the design makeup airflow at a pressure differential of 0.01 in. w.c. (3 Pa) or less.

SECTION M1504 EXHAUST DUCTS AND EXHAUST OPENINGS

M1504.1 Duct construction. Where exhaust duct construction is not specified in this chapter, construction shall comply with Chapter 16.

M1504.2 Duct length. The length of exhaust and supply ducts used with ventilating *equipment* shall not exceed the lengths determined in accordance with Table M1504.2. ~~Exhaust duct length shall comply with the manufacturer's design criteria, standard duct airflow design methods, or where the flow rate of the installed ventilating equipment is verified by the installer or approved third party using a flow hood, flow grid or other airflow measuring device.~~

Exception: Duct length shall not be limited where the *duct system* complies with the manufacturer's design criteria or where the flow rate of the installed ventilating *equipment* is verified by the installer or *approved* third party using a flow hood, flow grid or other airflow measuring device.

M1504.3 (501.3.1) Exhaust openings. Air exhaust openings shall terminate as follows:

1. Not less than 3 feet (914 mm) from property lines.
2. Not less than 3 feet (914 mm) from gravity air intake openings, operable windows and doors.
3. Not less than 10 feet (3048 mm) from mechanical air intake openings except where the exhaust opening is located not less than 3 feet (914 mm) above the air intake opening. Openings shall comply with Sections R303.5.2 and R303.6.

SECTION M1505 MECHANICAL VENTILATION

M1505.1 General. Where local exhaust or whole-house mechanical *ventilation* is ~~provided~~^{required}, the *ventilation system* shall be designed in accordance with this section. Refer to Section R303.1 for natural ventilation.

M1505.2 Recirculation of air. Exhaust air from bathrooms and toilet rooms shall not be recirculated within a residence or *circulated* to another *dwelling unit* and shall be exhausted directly to the outdoors. Exhaust air from bathrooms, toilet rooms and kitchens shall not discharge into an attic, *crawl space* or other areas inside the building. This section shall not prohibit the installation of ductless range hoods in accordance with the exception to Section M1503.3.

M1505.3 Exhaust equipment. Exhaust fans and whole-house mechanical ventilation fans shall be *listed* and *labeled* as providing the minimum required airflow in accordance with ANSI/AMCA 210-ANSI/ASHRAE 51.

M1505.4 Whole-house mechanical ventilation system. Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1505.4.1 through M1505.4.4.

M1505.4.1 System design. The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.

M1505.4.2 System controls. The whole-house mechanical ventilation system shall be provided with controls that enable manual override. Controls shall include text or a symbol indicating their function.

M1505.4.3 (403.3.2) Mechanical ventilation rate. The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate not less than that determined in accordance with Table M1505.4.3(1) or not less than that determined by Equation 15-1.

$$\text{Ventilation rate in cubic feet per minute} = (0.01 \times \text{total square foot area of house}) + [7.5 \times (\text{number of bedrooms} + 1)]$$

(Equation 15-1)

Exceptions:

1. Ventilation rate credit. The minimum mechanical ventilation rate determined in accordance with Table M1505.4.3(1) or Equation 15-1 shall be reduced by 30 percent, provided that both of the following conditions apply:
 - 1.1. A ducted system supplies ventilation air directly to each bedroom and to one or more of the following rooms:
 - 1.1.1. Living room.
 - 1.1.2. Dining room.
 - 1.1.3. Kitchen.
 - 1.2. The whole-house ventilation system is a balanced ventilation system.
2. Programmed intermittent operation. The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25 percent of each 4-hour segment and the ventilation rate prescribed in Table M1505.4.3(1), by Equation 15-1 or by Exception 1 is multiplied by the factor determined in accordance with Table M1505.4.3(2).

M1505.4.4 Local exhaust rates. Local exhaust systems shall be designed to have the capacity to exhaust the minimum airflow rate determined in accordance with Table M1505.4.4.

**TABLE M1505.4.4
MINIMUM REQUIRED LOCAL EXHAUST RATES FOR
ONE- AND TWO-FAMILY DWELLINGS**

AREA TO BE EXHAUSTED	EXHAUST RATES ^a
Kitchens	100 cfm intermittent or 25 cfm continuous
Bathrooms-Toilet Rooms	Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous

For SI: 1 cubic foot per minute = 0.0004719 m³/s,
1 inch water column = 0.2488 kPa.

- a. The listed exhaust rate for bathrooms-toilet rooms shall equal or exceed the exhaust rate at a minimum static pressure of 0.25 inch water column in accordance with Section M1505.3.

**TABLE M1502.4.6.1
DRYER EXHAUST DUCT FITTING EQUIVALENT LENGTH**

DRYER EXHAUST DUCT FITTING TYPE	EQUIVALENT LENGTH
4-inch radius mitered 45-degree elbow	2 feet 6 inches

4-inch radius mitered 90-degree elbow	5 feet
6-inch radius smooth 45-degree elbow	1 foot
6-inch radius smooth 90-degree elbow	1 foot 9 inches
8-inch radius smooth 45-degree elbow	1 foot
8-inch radius smooth 90-degree elbow	1 foot 7 inches
10-inch radius smooth 45-degree elbow	9 inches
10-inch radius smooth 90-degree elbow	1 foot 6 inches

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

TABLE M1504.2
DUCT LENGTH

DUCT TYPE	FLEX DUCT									SMOOTH-WALL DUCT							
	50	80	100	125	150	200	250	300	50	80	100	125	150	200	250	300	
Fan airflow rating (CFM @ 0.25 inch wc ^a)																	
Diameter ^b (inches)	Maximum length ^{c, d, e} (feet)																
3	X	X	X	X	X	X	X	X	X	5	X	X	X	X	X	X	X
4	56	4	X	X	X	X	X	X	X	114	31	10	X	X	X	X	X
5	NL	81	42	16	2	X	X	X	NL	152	91	51	28	4	X	X	
6	NL	NL	158	91	55	18	1	X	NL	NL	NL	168	112	53	25	9	
7	NL	NL	NL	NL	161	78	40	19	NL	NL	NL	NL	NL	NL	148	88	54
8 and above	NL	NL	NL	NL	NL	189	111	69	NL	NL	NL	NL	NL	NL	NL	198	133

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

a. Fan airflow rating shall be in accordance with ANSI/AMCA 210-ANSI/ASHRAE 51.

b. For noncircular ducts, calculate the diameter as four times the cross-sectional area divided by the perimeter.

c. This table assumes that elbows are not used. Fifteen feet of allowable duct length shall be deducted for each elbow installed in the duct run.

d. NL = no limit on duct length of this size.

e. X = not allowed. Any length of duct of this size with assumed turns and fittings will exceed the rated pressure drop.

TABLE M1505.4.3(1)

CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0-1	2-3	4-5	6-7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501-3,000	45	60	75	90	105
3,001-4,500	60	75	90	105	120

4,501–6,000	75	90	105	120	135
6,001–7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

For SI: 1 square foot = 0.0929 m², 1 cubic foot per minute = 0.0004719 m³/s.

TABLE M1505.4.3(2)

INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS^{a, b}

RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor ^a	4	3	2	1.5	1.3	1.0

- a. For ventilation system run-time values between those given, the factors are permitted to be determined by interpolation.
b. Extrapolation beyond the table is prohibited.

SECTION M15086 (512)
SUBSLAB SOIL EXHAUST SYSTEMS

M1508.1 (512.1) General. Where a subslab soil exhaust system is provided, the system shall conform to the requirements of this section.

M1508.2 (512.2) Materials. Subslab soil exhaust system duct material shall be air duct material *listed and labeled* to the requirements of UL 181 for Class 0 air ducts, or any of the following piping materials that comply with the *International Plumbing Code* as building sanitary drainage and vent pipe: cast iron; galvanized steel; ~~brass or copper pipe; copper or copper-alloy pipe and tube of a weight not less than that of copper drainage tube, Type DWV; and plastic piping.~~

M1508.3 (512.3) Grade. Exhaust system ducts shall not be trapped and shall have a minimum slope of one-eighth unit vertical in 12 units horizontal (1-percent slope).

M1508.4 (512.4) Termination. Subslab soil exhaust system ducts shall extend through the roof and terminate not less than 6 inches (152 mm) above the roof and not less than 10 feet (3048 mm) from any operable openings or air intake.

M1508.5 (512.5) Identification. Subslab soil exhaust ducts shall be permanently identified within each floor level by means of a tag, stencil or other *approved* marking.

User notes:

About this chapter: Chapter 16 addresses duct construction for HVAC and most exhaust systems. This chapter covers duct materials, duct construction, duct installation, duct insulation properties, duct sealing, above-ground and underground ducts, return air-intake locations and air plenums.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

SECTION M1601 DUCT CONSTRUCTION

M1601.1 (601.1) Duct design. Duct systems serving heating, cooling and ventilation equipment shall be installed in accordance with the provisions of this section and ACCA Manual D, the appliance manufacturer's installation instructions or other approved methods.

M1601.1.1 Above-ground duct systems. Above-ground duct systems shall conform to the following:

1. Equipment connected to duct systems shall be designed to limit discharge air temperature to not greater than 250°F (121°C).
2. Factory-made ducts shall be listed and labeled in accordance with UL 181 and installed in accordance with the manufacturer's instructions.
3. Fibrous glass duct construction shall conform to the SMACNA *Fibrous Glass Duct Construction Standards* or NAIMA *Fibrous Glass Duct Construction Standards*.
4. Field-fabricated and shop-fabricated metal and flexible duct constructions shall conform to the SMACNA *HVAC Duct Construction Standards—Metal and Flexible* except as allowed by Table M1601.1.1. Galvanized steel shall conform to ASTM A653. Domestic clothes dryer exhaust ducts shall have a minimum thickness as specified in Section M1502.4.1.
5. The use of gypsum products to construct return air ducts or plenums is permitted, provided that the air temperature does not exceed 125°F (52°C) and exposed surfaces are not subject to condensation.
6. Duct systems shall be constructed of materials having a flame spread index of not greater than 200.
7. Stud wall cavities and the spaces between solid floor joists to be used as air plenums shall comply with the following conditions:
 - 7.1. These cavities or spaces shall not be used as a plenum for supply air.
 - 7.2. These cavities or spaces shall not be part of a required fire-resistance-rated assembly.
 - 7.3. Stud wall cavities shall not convey air from more than one floor level.
 - 7.4. Stud wall cavities and joist-space plenums shall be isolated from adjacent concealed spaces by tight-fitting fireblocking in accordance with Section R302.11. Fireblocking materials used for isolation shall comply with Section R302.11.1.
 - 7.5. Stud wall cavities in the outside walls of building envelope assemblies shall not be utilized as air plenums.
 - 7.6. Building cavities used as plenums shall be sealed.
8. Volume dampers, equipment and other means of supply, return and exhaust air adjustment used in system balancing shall be provided with access.

M1601.1.2 (603.8) Underground duct systems. Underground duct systems shall be constructed of approved concrete, clay, metal or plastic. The maximum design temperature for systems utilizing plastic duct and fittings shall be 150°F (66°C). Metal ducts shall be protected from corrosion in an approved manner or shall be completely encased in concrete not less than 2 inches (51 mm) thick. Nonmetallic ducts shall be installed in accordance with the manufacturer's instructions. Plastic pipe and fitting materials shall conform to cell classification 12454-B of ASTM D1248 or ASTM D1784 and external loading properties of ASTM D2412. Ducts shall slope to a drainage

point that has access. Ducts shall be sealed, secured and tested prior to encasing the ducts in concrete or direct burial. Duct tightness shall be verified as required by Section N1103.3. Metallic ducts having an *approved* protective coating and nonmetallic ducts shall be installed in accordance with the manufacturer's instructions.

M1601.2 ~~604.4~~ Vibration isolators (Flexible connections). Vibration isolators (Flexible connectors) installed between mechanical equipment and metal ducts shall be fabricated from *approved* materials and shall not exceed 10 inches (254 mm) in length.

M1601.3 ~~604.4~~ Duct insulation materials. Duct insulation materials shall conform to the following requirements:

1. Duct coverings and linings, including adhesives where used, shall have a flame spread index not higher than 25, and a *smoke-developed index* not over 50 when tested in accordance with ASTM E84 or UL 723, using the specimen preparation and mounting procedures of ASTM E2231.

Exception: Spray application of polyurethane foam to the exterior of ducts in *attics* and *crawl spaces* shall be permitted subject to all of the following:

1. The flame spread index is not greater than 25 and the *smoke-developed index* is not greater than 450 at the specified installed thickness.
 2. The foam plastic is protected in accordance with the ignition barrier requirements of Sections R316.5.3 and R316.5.4.
 3. The foam plastic complies with the requirements of Section R316.
2. Duct coverings and linings shall not flame, glow, smolder or smoke when tested in accordance with ASTM C411 at the temperature to which they are exposed in service. The test temperature shall not fall below 250°F (121°C). Coverings and linings shall be *listed* and *labeled*.
 3. External reflective duct insulation shall be legibly printed or identified at intervals not greater than 36 inches (914 mm) with the name of the manufacturer, the product *R*-value at the specified installed thickness and the flame spread and smoke-developed indices. The installed thickness of the external duct insulation shall include the enclosed airspace(s). The product *R*-value for external reflective duct insulation shall be determined in accordance with ASTM C1668.
 4. External duct insulation and factory-insulated flexible ducts shall be legibly printed or identified at intervals not longer than 36 inches (914 mm) with the name of the manufacturer, the thermal resistance *R*-value at the specified installed thickness and the flame spread and smoke-developed *indices* of the composite materials. Spray polyurethane foam manufacturers shall provide the same product information and properties, at the nominal installed thickness, to the customer in writing at the time of foam application. Nonreflective duct insulation product *R*-values shall be based on insulation only, excluding air films, vapor retarders or other duct components, and shall be based on tested *C*-values at 75°F (24°C) mean temperature at the installed thickness, in accordance with recognized industry procedures. The installed thickness of duct insulation used to determine its *R*-value shall be determined as follows:
 - 4.1. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.
 - 4.2. For ductwrap, the installed thickness shall be assumed to be 75 percent (25-percent compression) of nominal thickness.
 - 4.3. For factory-made flexible air ducts, The installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.
 - 4.4. For spray polyurethane foam, the aged *R*-value per inch measured in accordance with recognized industry standards shall be provided to the customer in writing at the time of foam application. In addition, the total *R*-value for the nominal application thickness shall be provided.

M1601.4.1 Joints, seams and connections. Longitudinal and transverse joints, seams and connections in metallic and nonmetallic ducts shall be constructed as specified in SMACNA *HVAC Duct Construction Standards—Metal and Flexible* and NAIMA *Fibrous Glass Duct Construction Standards*. Joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, liquid sealants or tapes. Tapes and mastics used to seal fibrous glass ductwork shall be *listed* and *labeled* in accordance with UL 181A and shall be marked “181A-P” for pressure-sensitive tape, “181 A-M” for mastic or “181 A-H” for heat-sensitive tape.

Tapes and mastics used to seal metallic and flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked “181 B-FX” for pressure-sensitive tape or “181 BM” for mastic. Duct connections to flanges of air distribution system *equipment* shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply with UL 181B and shall be marked 181B-C. Crimp joints for round metallic ducts shall have a contact lap of not less than 1 inch (25 mm) and shall be mechanically fastened by means of not less than three sheet-metal screws or rivets equally spaced around the joint. Unlisted duct tape is not permitted as a sealant on any metal ducts.

Closure systems used to seal all ductwork shall be installed in accordance with the manufacturers’ instructions.

Exceptions:

1. Spray polyurethane foam shall be permitted to be applied without additional joint seals.
2. Where a duct connection is made that is partially **without access**, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.
3. ~~For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams and locking type joints and seams. This exception shall not apply to snap lock and button lock type joints and seams that are located outside of conditioned spaces. Deleted.~~
- ~~4. Continuously welded joints and seam in ducts.~~
- ~~5. Ducts exposed within the conditioned space that the ducts serve shall not be required to be sealed.~~

M1601.4.2 Duct lap. Crimp joints for round and oval metal ducts shall be lapped not less than 1 inch (25 mm) **and the male end of the duct shall extend into the adjoining duct in the direction of airflow.**

M1601.4.4 Support. Factory-made ducts *listed* in accordance with UL 181 shall be supported in accordance with the manufacturer’s installation instructions. Field- and shop-fabricated fibrous glass ducts shall be supported in accordance with the SMACNA *Fibrous Glass Duct Construction Standards* or the NAIMA *Fibrous Glass Duct Construction Standards*. Field- and shop-fabricated metal and flexible ducts shall be supported in accordance with the SMACNA *HVAC Duct Construction Standards—Metal and Flexible* or in accordance with Section M1601.4.4.1.

All *appliances and equipment* shall be supported independently of the duct system except when the duct is used as a support base. When used as a support base, the duct shall be of sufficient strength and designed to support the weight of the unit. Listed bases shall be installed in accordance with the manufacturer’s installation instructions.

M1601.4.4.1 ~~(603.10.1)~~ Metal duct minimal support. Metal ducts shall be securely supported. Where hung or suspended, metal straps a minimum of 1 inch (25 mm) in width and equivalent to or heavier gage than the duct being supported shall be used. Straps, when used, shall be at maximum 64-inch (1626 mm) intervals and shall be securely attached to the building structure. Straps shall be attached to the duct at a minimum of two points with screws or rivets.

M1601.4.5 Fireblocking. Duct installations shall be fireblocked in accordance with Section **R302.11**.

M1601.4.6 ~~(604.1)~~ Duct insulation. Duct insulation shall be installed in accordance with the following requirements:

1. A vapor retarder having **a permeance of not greater than 0.05 perm** [2.87 ng/(s × m² × Pa)] in accordance with ASTM E96, or aluminum foil with **a thickness of not less than 2 mils (0.05 mm)**, shall be installed on the exterior of insulation on cooling supply ducts that pass through unconditioned spaces conducive to condensation except where the insulation is spray polyurethane foam with **a water vapor permeance of not greater than 3 perms** per inch [1722 ng/(s × m² × Pa)] at the installed thickness.
2. **Outdoor duct systems** shall be protected against the elements.
3. Duct coverings shall not penetrate a fireblocked wall or floor.

Replacement or addition of cooling equipment to existing ductwork located in an attic shall require the ductwork to be insulated. Replacement of heating or the addition of cooling equipment in a crawl space or conditioned basements shall not require the existing ductwork to be insulated. Unconditioned basement ductwork shall require insulation with the addition of cooling equipment.

M1601.4.8 (603.14) Duct separation. Ducts shall be installed with not less than 4 inches (102 mm) separation from earth except where they meet the requirements of Section M1601.1.2.

M1601.4.10 Flood hazard areas. In flood hazard areas as established by Table R301.2, *duct systems* shall be located or installed in accordance with Section R322.1.6.

M1601.4.11 Condensation. Provisions shall be made to prevent the formation of condensation on the exterior of any newly-installed duct. Newly-installed ducts insulated in accordance with Chapter 11 shall be deemed to meet the intent of this section.

M1601.5.1 General. The space shall be cleaned of loose *combustible materials* and scrap, and shall be tightly enclosed. The ground surface of the space shall be covered with a moisture barrier having a thickness of not less than 4 mils (0.1 mm). Plumbing waste cleanouts shall not be located within the space.

Exception: Plumbing waste cleanouts shall be permitted to be located in unvented *crawl spaces* that receive *conditioned air* in accordance with Section R408.39.

M1602.2 Return air openings. Return air openings for heating, *ventilation* and air-conditioning systems shall comply with all of the following:

1. Openings shall not be located less than 10 feet (3048 mm) measured in any direction from an open combustion chamber, *including factory-built and masonry fireplaces* or draft hood of another *appliance* located in the same room or space.
2. The amount of return air taken from any room or space shall be not greater than the flow rate of supply air delivered to such room or space.
3. Return and transfer openings shall be sized in accordance with the *appliance* or *equipment* manufacturers installation instructions, Manual D or the design of the *registered design professional*.
4. Return air shall not be taken from a closet, bathroom, toilet room, kitchen, garage, mechanical room, boiler room, furnace room, *crawl space* or unconditioned attic.

Exceptions:

1. Taking return air from a kitchen is not prohibited where such return air openings serve the kitchen only, and are located not less than 10 feet (3048 mm) from the cooking *appliances*.
2. Dedicated forced-air systems serving only the garage shall not be prohibited from obtaining return air from the garage.
- ~~3. Deleted~~
5. For other than dedicated HVAC systems, return air shall not be taken from indoor swimming pool enclosures and associated deck areas except where the air in such spaces is dehumidified.
- ~~6. Taking return air from an unconditioned *crawl space* shall not be accomplished through a direct connection to the return side of a forced-air furnace. Transfer openings in the *crawl space* enclosure shall not be prohibited.~~
- ~~7. Return air from one *dwelling unit* shall not be discharged into another *dwelling unit*.~~

M1602.3 (603.18) Return-air intake (nonengineered systems). If only one central return-air grille is installed, it shall be of a size sufficient to return a volume of air compatible with the CFM requirements and the temperature rise limitations specified by the equipment manufacturer. The face velocity of return air grilles shall not exceed 450 feet per minute (fpm) (2.3 m/s). At least one separate return shall be installed on each level of a multi-level structure. For split-level and split-foyer structures, one return may serve more than one level if located within the split area and the total area of the levels does not exceed 1,600 square feet (148.6 m²). Return-air grilles shall not be located in bathrooms. The return air from one residential living unit shall not be mixed with the return air from other living units.

In dwellings with 1,600 square feet (148.6m²) or less of conditioned area, a central return is permitted. When the dwelling contains more than 1,600 square feet (148.6m²) of conditioned area, additional returns shall be provided. Each return shall serve not more than 1,600 square feet (148.6 m²) of area and shall be located in the area it serves.

Return air may travel through the living space to the return-air intake if there are no restrictions, such as solid doors, to the air movement. Undercut doors are allowed. When panned joists are used for return air, the structural integrity shall be maintained. Air capacity for joists 16 inches (406 mm) on center shall be a maximum of 375 cubic feet per minute (0.177 m³/s) for 8-inch (203 mm) joists and 525 cubic feet per minute (0.248 m³/s) for 10-inch (254 mm) joists. Wiring located in spaces used for return-air ducts shall comply with the *North Carolina Electrical Code*.

TABLE M1601.1.1
DUCT CONSTRUCTION MINIMUM SHEET METAL THICKNESS FOR SINGLE DWELLING UNITS^a

ROUND DUCT DIAMETER (inches)	STATIC PRESSURE			
	1/2-inch water gauge		1-inch water gauge	
	Thickness (inches)		Thickness (inches)	
	Galvanized	Aluminum	Galvanized	Aluminum
< 12	0.013 (30 ga.)	0.018 (24 ga.)	0.013 (30 ga.)	0.018 (24 ga.)
12 to 14	0.013 (30 ga.)	0.018 (24 ga.)	0.016 (28 ga.)	0.023 (22 ga.)
15 to 17	0.016 (28 ga.)	0.023 (22 ga.)	0.019 (26 ga.)	0.027 (20 ga.)
18	0.016 (28 ga.)	0.023 (22 ga.)	0.024 (24 ga.)	0.034 (18 ga.)
19 to 20	0.019 (26 ga.)	0.027 (20 ga.)	0.024 (24 ga.)	0.034 (18 ga.)
RECTANGULAR DUCT DIMENSION (inches)	STATIC PRESSURE			
	1/2-inch water gauge		1-inch water gauge	
	Thickness (inches)		Thickness (inches)	
	Galvanized	Aluminum	Galvanized	Aluminum
≤ 8	0.013 (30 ga.)	0.018 (24 ga.)	0.013 (30 ga.)	0.018 (24 ga.)
9 to 10	0.013 (30 ga.)	0.018 (24 ga.)	0.016 (28 ga.)	0.023 (22 ga.)
11 to 12	0.016 (28 ga.)	0.023 (22 ga.)	0.019 (26 ga.)	0.027 (20 ga.)
13 to 16	0.019 (26 ga.)	0.027 (20 ga.)	0.019 (26 ga.)	0.027 (20 ga.)
17 to 18	0.019 (26 ga.)	0.027 (20 ga.)	0.024 (24 ga.)	0.034 (18 ga.)
19 to 20	0.024 (24 ga.)	0.034 (18 ga.)	0.024 (24 ga.)	0.034 (18 ga.)

For SI: 1 inch = 25.4 mm, 1 inch water gage = 249 Pa.

- a. Ductwork that exceeds 20 inches by dimension or exceeds a pressure of 1 inch water gauge shall be constructed in accordance with SMACNA *HVAC Duct Construction Standards—Metal and Flexible*.

**TABLE 603.4
DUCT CONSTRUCTION MINIMUM SHEET METAL THICKNESS FOR SINGLE DWELLING UNITS**

DUCT SIZE	MINIMUM THICKNESS (inches)	EQUIVALENT GAGE (GALVANIZED)	ALUMINUM MINIMUM THICKNESS (inches) [gage]
<u>Round ducts and enclosed rectangular ducts</u>			
<u>14 inches or less</u>	<u>0.013</u>	<u>30</u>	<u>0.0159 [26 ga]</u>
<u>Over 14 inches</u>	<u>0.016</u>	<u>28</u>	<u>0.0201 [24 ga]</u>
<u>Exposed rectangular ducts</u>			
<u>14 inches or less</u>	<u>0.016</u>	<u>28</u>	<u>0.0201 [24 ga]</u>
<u>Over 14 inches</u>	<u>0.019</u>	<u>26</u>	<u>0.0253 [22 ga]</u>

For SI: 1 inch = 25.4 mm.

User notes:

About this chapter: Chapter 17 applies only to oil-fired and solid fuel-fired appliances. Chapter 24 applies to combustion air for gas-fired appliances.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page vi.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M1701.3 (701.2) Dampered openings. Where combustion air openings are provided with volume dampers, the dampers shall be interlocked with the firing cycle of the *appliances* served, so as to prevent operation of any *appliance* that draws combustion air from the room or space when any of the dampers are closed. Manual dampers shall not be installed in combustion air ducts.

User notes:

About this chapter: Chapter 18 addresses chimneys and vents that serve oil- and solid fuel-fired appliances, including wood pellet appliances. Gas-fired appliances are vented in accordance with Chapter 24. Chapter 10 addresses chimneys for fireplaces and masonry and factory-built chimneys in general. Note that chimneys and vents are distinct.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M1801.1 (801.1) Venting required. Fuel-burning *appliances* shall be vented to the outdoors in accordance with their *listing* and *label* and manufacturer's installation instructions except *appliances* listed and *labeled* for unvented use. Venting systems shall consist of *approved* chimneys or vents, or venting assemblies that are integral parts of *labeled appliances*. Gas-fired *appliances* shall be vented in accordance with Chapter 24.

M1801.3.3 (801.13) Cleanout. Masonry chimneys shall be provided with a cleanout opening complying with Section R1003.17.

M1801.3.4 (801.18.4) Clearances. Chimneys and vents shall have airspace clearance to combustibles in accordance with this code and the chimney or vent manufacturer's installation instructions.

Exception: Masonry chimneys equipped with a chimney lining system tested and *listed* for installation in chimneys in contact with combustibles in accordance with UL 1777, and installed in accordance with the manufacturer's instructions, shall not be required to have a clearance between *combustible materials* and exterior surfaces of the *masonry chimney*. Noncombustible firestopping shall be provided in accordance with this code.

M1801.4 (801.17) Space around lining. The space surrounding a flue lining system or other vent installed within a *masonry chimney* shall not be used to vent any other *appliance*. This shall not prevent the installation of a separate flue lining in accordance with the manufacturer's installation instructions and this code.

M1801.5 Mechanical draft systems. A *mechanical draft system* shall be used only with *appliances listed and labeled* for such use. Provisions shall be made to prevent the flow of fuel to the *equipment* when the draft system is not operating. Forced draft systems and portions of induced draft systems under positive pressure during operation shall be designed and installed to prevent leakage of flue gases into a building.

M1801.11 Multiple-appliance venting systems. Two or more *listed and labeled appliances* connected to a common natural draft venting system shall comply with the following requirements:

1. *Appliances* that are connected to common venting systems shall be located on the same floor of the *dwelling*.
Exception: Engineered systems as provided for in Section G2427.
2. Inlets to common venting systems shall be offset such that no portion of an inlet is opposite another inlet.
3. *Connectors* serving *appliances* operating under a natural draft shall not be connected to any portion of a *mechanical draft system* operating under positive pressure.

M1802.4 Blocked vent switch. Oil-fired *appliances* shall be equipped with a device that will stop burner operation in the event that the venting system is obstructed. Such device shall have a manual reset and shall be installed in accordance with the manufacturer's instructions.

M1803.2 (803.9) Connectors for oil and solid fuel-burning appliances. Connectors for oil and solid fuel-burning *appliances* shall be constructed of *factory-built chimney* material, Type L vent material or single-wall metal pipe

having resistance to corrosion and heat and thickness not less than that of galvanized steel as specified in Table M1803.2.

TABLE M1803.2 (803.9(4))

THICKNESS FOR SINGLE-WALL METAL PIPE CONNECTORS

DIAMETER OF CONNECTOR (inches)	GALVANIZED SHEET METAL GAGE NUMBER	MINIMUM THICKNESS (inch)
Less than 6	26	0.019
6 to 10	24	0.024
Over 10 through 16	22	0.029

For SI: 1 inch = 25.4 mm.

M1803.3 (803.10.5) Installation. Vent and chimney connectors shall be installed in accordance with the manufacturer's instructions and within the space where the *appliance* is located. *Appliances* shall be located as close as practical to the vent or chimney. Connectors shall be as short and straight as possible and installed with a slope of not less than 1/4 inch (6 mm) rise per foot of run. Connectors shall be securely supported and joints shall be fastened with sheet metal screws or rivets. Devices that obstruct the flow of flue gases shall not be installed in a connector unless *listed and labeled or approved* for such **installation**.

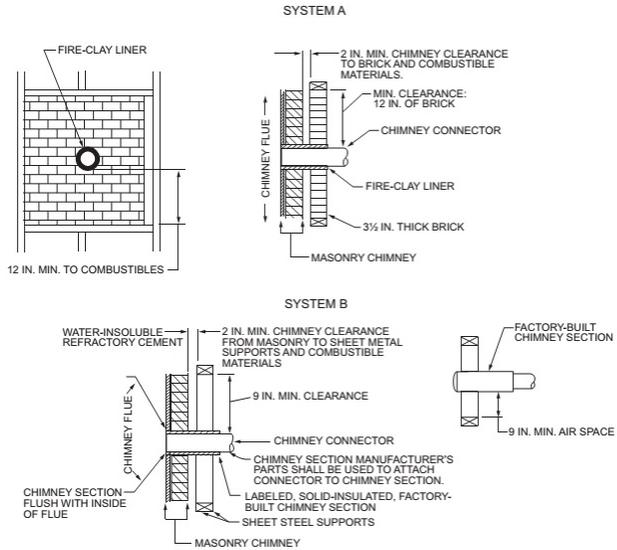
M1803.3.1 (803.10.4) Floor, ceiling and wall penetrations. A chimney connector or vent connector shall not pass through any floor or ceiling. A chimney connector or vent connector shall not pass through a wall or partition unless the connector is *listed and labeled* for wall pass-through, or is routed through a device *listed and labeled* for wall pass-through and is installed in accordance with the conditions of its *listing and label*. Connectors for oil-fired *appliances listed and labeled* for Type L vents, passing through walls or partitions shall be in accordance with the following:

1. Type L vent material for oil *appliances* shall be installed with not less than *listed and labeled* clearances to *combustible material*.
2. Single-wall metal pipe shall be *guarded* by a ventilated metal thimble not less than 4 inches (102 mm) larger in diameter than the vent connector. **Not less than** 6 inches (152 mm) of clearance shall be maintained between the thimble and combustibles.

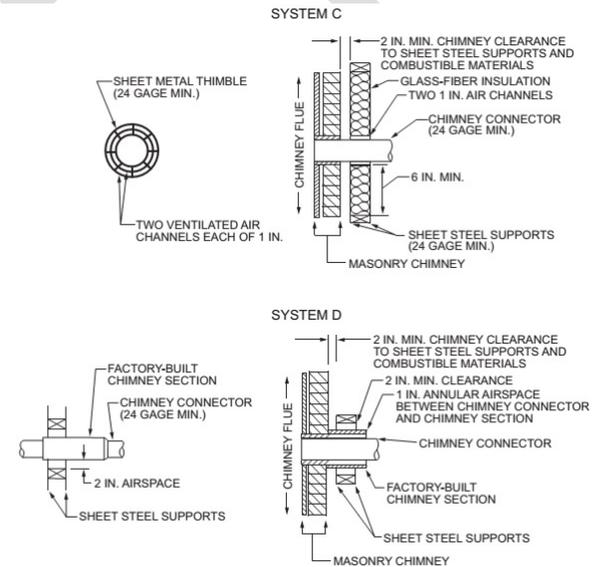
M1803.3.4 (803.10.6) Clearance. Connectors shall be installed with clearance to combustibles as set forth in Table M1803.3.4 **or Table M1803.3.5**. Reduced clearances to **combustible materials** shall be in accordance with Table M1306.2 and Figure M1306.1.

M1803.3.5 Connector pass-through. **Chimney connectors shall not pass through any floor or ceiling, nor through a fire-resistance-rated wall assembly. Chimney connectors for domestic-type appliances shall not pass through walls or partitions constructed of combustible material to reach a masonry chimney except where one of the following applies:**

- 1. The connector is labeled for wall pass-through and is installed in accordance with the manufacturer's instructions.**
- 2. The connector is put through a device labeled for wall pass-through.**
- 3. The connector has a diameter not larger than 10 inches (254 mm) and is installed in accordance with one of the methods in Table M1803.3.5. Concealed metal parts of the pass-through system in contact with flue gases shall be of stainless steel or equivalent material that resists corrosion, softening or cracking up to 1,800°F (980°C).**



For SI: 1 inch = 25.4 mm.



For SI: 1 inch = 25.4 mm.

FIGURE M1803.3.5
CHIMNEY CONNECTOR SYSTEMS

TABLE M1803.3.5 (803.40.4)
CHIMNEY CONNECTOR SYSTEMS AND CLEARANCES TO COMBUSTIBLE WALL MATERIALS FOR DOMESTIC HEATING APPLIANCES^{a, b, c, d}

<p>System A (12-inch clearance)</p>	<p>A 3.5-inch-thick brick wall shall be framed into the combustible wall. An 0.625-inch-thick fire-clay liner (ASTM C315 or equivalent)^e shall be firmly cemented in the center of the brick wall maintaining a 12-inch clearance to combustibles. The clay liner shall run from the outer surface of the bricks to the inner surface of the chimney liner.</p>
<p>System B (9-inch clearance)</p>	<p>A labeled solid-insulated factory-built chimney section (1-inch insulation) the same inside diameter as the connector shall be utilized. Sheet steel supports cut to maintain a 9-inch clearance to combustibles shall be fastened to the wall surface and to the chimney section. Fasteners shall not penetrate the chimney flue liner. The chimney length shall be flush with the masonry chimney liner and sealed to the masonry with water-insoluble</p>

	<u>refractory cement. Chimney manufacturers' parts shall be utilized to securely fasten the chimney connector to the chimney section.</u>
System C (6-inch clearance)	<u>A steel ventilated thimble having a minimum thickness of 0.0236 inch (No. 24 gage) having two 1-inch air channels shall be installed with a steel chimney connector. Steel supports shall be cut to maintain a 6-inch clearance between the thimble and combustibles. The chimney connector and steel supports shall have a minimum thickness of 0.0236 inch (No. 24 gage). One side of the support shall be fastened to the wall on all sides. Glass-fiber insulation shall fill the 6-inch space between the thimble and the supports.</u>
System D (2-inch clearance)	<u>A labeled solid-insulated factory-built chimney section (1-inch insulation) with a diameter 2 inches larger than the chimney connector shall be installed with a steel chimney connector having a minimum thickness of 0.0236 inch (No. 24 gage). Sheet steel supports shall be positioned to maintain a 2-inch clearance to combustibles and to hold the chimney connector to ensure that a 1-inch airspace surrounds the chimney connector through the chimney section. The steel support shall be fastened to the wall on all sides and the chimney section shall be fastened to the supports. Fasteners shall not penetrate the liner of the chimney section.</u>

For SI: 1 inch = 25.4 mm, 1.0 Btu · in/ft² · h · °F = 0.144 W/m² · K.

- a. Insulation material that is part of the wall pass-through system shall be noncombustible and shall have a thermal conductivity of 1.0 Btu · in/ft² · h · °F or less.
- b. All clearances and thicknesses are minimums.
- c. Materials utilized to seal penetrations for the connector shall be noncombustible.
- d. Connectors for all systems except System B shall extend through the wall pass-through system to the inner face of the flue liner.
- e. ASTM C315.

M1803.3.56 Access. The entire length of a connector shall allow access for inspection, cleaning and replacement.

M1803.4.2 Connection to factory-built fireplace flue. A different *appliance* shall not be connected to a flue serving a factory-built fireplace unless the *appliance* is specifically *listed* for such an installation. The connection shall be made in compliance with the *appliance* manufacturer's instructions.

M1803.4.3 Connection to masonry fireplace flue. A connector shall extend from the *appliance* to the flue serving a masonry fireplace to convey the flue gases directly into the flue. The connector shall be provided with access or shall be removable for inspection and cleaning of both the connector and the flue. *Listed* direct-connection devices shall be installed in accordance with their *listing*.

TABLE M1804.1
VENT SELECTION CHART

VENT TYPES	APPLIANCE TYPES
Type L oil vents	Oil-burning appliances <i>listed</i> and <i>labeled</i> for venting with Type L vents
Pellet vents	Pellet fuel-burning appliances <i>listed</i> and <i>labeled</i> for use with pellet vents

M1804.1.1 (801.20) Plastic vent joints. Plastic pipe and fittings used to vent appliances shall be installed in accordance with the *appliance* manufacturer's installation instructions. Solvent cement joints between ABS pipe and fittings shall be cleaned. Solvent cement joints between CPVC pipe and fittings or PVC pipe and fittings shall be primed. The primer shall be a contrasting color, or an ultraviolet primer may be used.

M1804.2.6 Mechanical draft systems. *Mechanical draft systems* shall comply with UL 378 and shall be installed in accordance with their *listing*, the manufacturer's instructions and, except for direct-vent *appliances*, the following requirements: Sections M1804.2.6.1 through M1804.2.6.3.

1. The vent terminal shall be located not less than 3 feet (914 mm) above a forced air inlet located within 10 feet (3048 mm).
2. The vent terminal shall be located not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from, or 1 foot (305 mm) above any door, window or gravity air inlet into a *dwelling*.
3. The vent termination point shall be located not closer than 3 feet (914 mm) to an interior corner formed by two walls perpendicular to each other.
4. The bottom of the vent terminal shall be located not less than 12 inches (305 mm) above finished ground level.
5. The vent termination shall not be mounted directly above or within 3 feet (914 mm) horizontally of an oil tank vent or gas meter.
6. Power exhauster terminations shall be located not less than 10 feet (3048 mm) from *lot lines* and adjacent buildings.
7. The discharge shall be directed away from the building.

M1804.2.6.1 (804.3.4) Horizontal terminations. Vertical terminations shall comply with the following requirements:

1. Where located adjacent to walkways, the termination of mechanical draft systems shall be not less than 7 feet (2134 mm) above the level of the walkway.
2. Vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).
3. The vent system shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet into the building.
4. The vent termination point shall not be located closer than 3 feet (914 mm) to an interior corner formed by two walls perpendicular to each other.
5. The vent termination shall not be mounted directly above or within 3 feet (914 mm) horizontally from an oil tank vent or gas meter.
6. The bottom of the vent termination shall be located not less than 12 inches (305 mm) above finished grade.

M1804.2.6.2 (804.3.5) Vertical terminations. Vertical terminations shall comply with the following requirements:

1. Where located adjacent to walkways, the termination of mechanical draft systems shall be not less than 7 feet (2134 mm) above the level of the walkway.
2. Vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm) horizontally.
3. Where the vent termination is located below an adjacent roof structure, the termination point shall be located not less than 3 feet (914 mm) from such structure.
4. The vent shall terminate not less than 4 feet (1219 mm) below, 4 feet (1219 mm) horizontally from or 1 foot (305 mm) above any door, window or gravity air inlet for the building.
5. A vent cap shall be installed to prevent rain from entering the vent system.
6. The vent termination shall be located not less than 3 feet (914 mm) horizontally from any portion of the roof structure.

M1804.2.6.3 (804.3.8) Mechanical draft systems for manually fired appliances and fireplaces. A mechanical draft system shall be permitted to be used with manually fired appliances and fireplaces where such system complies with all of the following requirements:

1. The mechanical draft device shall be listed and labeled in accordance with UL 378, and shall be installed in accordance with the manufacturer's instructions.
2. A device shall be installed that produces visible and audible warning upon failure of the mechanical draft device or loss of electrical power, at any time that the mechanical draft device is

turned on. This device shall be equipped with a battery backup if it receives power from the building wiring.

3. A smoke detector shall be installed in the room with the appliance or fireplace. This device shall be equipped with a battery backup if it receives power from the building wiring.

M1804.4 Door swing. Appliance and *equipment* vent terminals shall be located such that doors cannot swing within 12 inches (305 mm) horizontally of the vent terminals. Door stops or closers shall not be installed to obtain this clearance.

M1805.2 ~~(803.10.3)~~ Masonry chimney connection. A chimney connector shall enter a *masonry chimney* not less than 6 inches (152 mm) above the bottom of the chimney. Where it is not possible to locate the connector entry **not less than** 6 inches (152 mm) above the bottom of the chimney flue, a cleanout shall be provided by installing a capped tee in the connector next to the chimney. A connector entering a *masonry chimney* shall extend through, but not beyond, the wall and shall be flush with the inner face of the liner. Connectors, or thimbles where used, shall be firmly cemented into the masonry.

M1805.4 ~~(805.6)~~ 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.

M1805.5 Insulation shield. Where factory-built chimneys pass through insulated assemblies, an insulation shield constructed of steel having a thickness of not less than 0.0187 inch (0.4712 mm) (No. 26 gage) shall be installed to provide clearance between the chimney and the insulation material. The clearance shall be not less than the clearance to combustibles specified by the chimney manufacturer's installation instructions. Where chimneys pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the insulation materials and shall be secured in place to prevent displacement. Insulation shields provided as part of a listed chimney system shall be installed in accordance with the manufacturer's instructions.

User notes:

— **About this chapter:** Chapter 19 is specific to appliances and systems that are not related to HVAC, including cooking appliances, sauna heaters, fuel cells and hydrogen systems. Chapter 24 also applies to cooking appliances and sauna heaters.

— **Code development reminder:** Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M1901.1 Clearances. Freestanding or built-in ranges shall have a vertical clearance above the cooking top of not less than 30 inches (762 mm) to unprotected *combustible material*. Reduced clearances are permitted in accordance with the *listing* and *labeling* of the range hoods or *ovens with integral exhaust*.

M1901.2 (917.2) Cooking appliances. Cooking *appliances* shall be *listed* and *labeled* for household use and shall be installed in accordance with the manufacturer's instructions. The installation shall not interfere with *combustion air* or access for operation and servicing. Electric cooking *appliances* shall comply with UL 858 or UL 1026. Solid-fuel-fired fireplace stoves shall comply with UL 737. *Microwave ovens shall comply with UL 923.*

M1901.3 (917.3) Installation of microwave oven over a cooking appliance. The installation of a *listed and labeled* cooking appliance or microwave oven over a *listed and labeled* cooking appliance shall conform to the terms of the upper appliance's *listing* and *label* and the manufacturer's installation instructions.

M1902.1 (914.1) Locations and protection. Sauna heaters shall be protected from accidental contact by persons with a guard of material having a low thermal conductivity, such as wood. The guard shall not have a substantial effect on the transfer of heat from the heater to the room.

M1902.2 (914.2) Installation. Sauna heaters shall be installed in accordance with the manufacturer's instructions. Sauna heaters shall comply with UL 875.

M1902.5 (914.5) Sauna room. A ventilation opening into the sauna room shall be provided as required by the manufacturer.

M1903.1 (924.1) General. Stationary fuel cell power plants having a power output not exceeding 1,000 kW, shall comply with ANSI/CSA America FC 1 and shall be installed in accordance with the manufacturer's instructions and NFPA 853.

M1904.1 (926.1) Installation. Gaseous hydrogen systems shall be installed in accordance with the applicable requirements of Sections M1307.4 and M1903.1, the *International Building Code*, the *International Fire Code* and the *International Fuel Gas Code*.

User notes:

About this chapter: Chapter 20 is specific to boilers and water heaters. The provisions of this chapter apply to appliances generally without regard to the energy source. Gas-fired boilers and water heaters are also addressed in Chapter 24; therefore, Chapters 20 and 24 both apply to such appliances.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page vi.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M2001.1.1 Standards. Packaged oil-fired boilers shall be *listed* and *labeled* in accordance with UL 726. Packaged electric boilers shall be *listed* and *labeled* in accordance with UL 834. Solid fuel-fired boilers shall be *listed* and *labeled* in accordance with UL 2523. Boilers shall be designed, constructed and certified in accordance with the *ASME Boiler and Pressure Vessel Code*, Section I or IV. Controls and safety devices for boilers with fuel input ratings of 12,500,000 Btu/hr (3663 kW) or less shall meet the requirements of ASME CSD-1. Gas-fired boilers shall conform to the requirements listed in Chapter 24.

M2002.1 (1006.4) Safety controls. Electrical and mechanical operating and safety controls for boilers shall be *listed* and *labeled*.

M2002.2 (1010.1) Hot water boiler gauges. Every hot water boiler shall have a pressure gauge and a temperature gauge, or combination pressure and temperature gauge. The gauges shall indicate the temperature and pressure within the normal range of the system's operation.

M2002.3 (1010.2) Steam boiler gauges. Every steam boiler shall have a water-gauge glass and a pressure gauge. The pressure gauge shall indicate the pressure within the normal range of the system's operation. The gauge glass shall be installed so that the midpoint is at the normal water level.

M2002.4 Pressure-relief valve. Boilers shall be equipped with pressure-relief valves with minimum rated capacities for the equipment served. Pressure-relief valves shall be set at the maximum rating of the boiler. Discharge shall be piped to drains by gravity to within 18 inches (457 mm) of the floor or to an open receptor.

M2002.5 (1007.1) Boiler low-water cutoff. Steam and hot water boilers shall be protected with a low-water cutoff control.

Exception: A low-water cutoff is not required for coil-type and water-tube-type boilers that require forced circulation of water through the boiler and that are protected with a flow-sensing control.

M2002.6 Operation. Low-water cutoff controls and flow-sensing controls required by Section M2002.5 shall automatically stop the combustion operation of the *appliance* when the water level drops below the lowest safe water level as established by the manufacturer or when the water circulation flow is less than that required for safe operation of the *appliance*, respectively.

M2003.1.1 Pressurized expansion tanks. Pressurized expansion tanks shall be consistent with the volume and capacity of the system. Tanks shall be capable of with-standing a hydrostatic test pressure of two and one-half times the allowable working pressure of the system.

TABLE M2003.2
EXPANSION TANK MINIMUM CAPACITY^a
FOR FORCED HOT-WATER SYSTEMS

SYSTEM VOLUME ^b (gallons)	PRESSURIZED DIAPHRAGM TYPE	NONPRESSURIZED TYPE
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10	1.0	1.5
20	1.5	3.0
30	2.5	4.5
40	3.0	6.0
50	4.0	7.5
60	5.0	9.0
70	6.0	10.5
80	6.5	12.0
90	7.5	13.5
100	8.0	15.0

For SI: 1 gallon = 3.785 L, 1 pound per square inch gauge = 6.895 kPa,
 $^{\circ}\text{C} = [(^{\circ}\text{F}) - 32]/1.8$.

- a. Based on average water temperature of 195°F, fill pressure of 12 psig and an operating pressure of not greater than 30 psig.
- b. System volume includes volume of water in boiler, convectors and piping, not including the expansion tank.

M2004.1 General. Water heaters used to supply both potable hot water and hot water for space heating shall be installed in accordance with this chapter, Chapter 24, Chapter 28 and the manufacturer's instructions. Water heaters utilized both to supply potable hot water and provide hot water for space heating applications shall be listed and labeled for such applications by the manufacturer and shall be installed in accordance with the manufacturer's instructions and the *International Plumbing Code*.

M2004.1.1 (1002.2.1) Sizing. Water heaters utilized for both potable water heating and space-heating applications shall be sized to prevent the space-heating load from diminishing the required potable water-heating capacity.

M2004.1.2 (1002.2.2) Temperature limitation. Where a combination potable water-heating and space-heating system requires water for space heating at temperatures higher than 140°F (60°C), a temperature-actuated mixing valve that conforms to ASSE 1017 shall be provided to temper the water supplied to the potable hot water distribution system to a temperature of 140°F (60°C) or less.

M2004.2 (1002.3) Supplemental water heating devices. Potable water heating devices that utilize refrigerant to-water heat exchangers shall be approved and installed in accordance with the *International Plumbing Code* and the manufacturer's instructions.

M2005.1 (1002.1) General. Water heaters shall be installed in accordance with Chapter 28, the manufacturer's instructions and the requirements of this code. Water heaters installed in an attic shall comply with the requirements of Section M1305.1.2. Gas-fired water heaters shall comply with the requirements in Chapter 24. Domestic electric water heaters shall comply with UL 174. Oiled-fired water heaters shall comply with UL 732. Solar thermal water heating systems shall comply with Chapter 23 and ICC 900/SRCC 300. Solid fuel-fired water heaters shall comply with UL 2523.

M2005.2 Prohibited locations. Fuel-fired water heaters shall not be installed in a room used as a storage closet. Water heaters located in a room or space accessed only through a bedroom or bathroom shall be installed in a scaled enclosure so that combustion air will not be taken from the living space accordance with Section G2406.2. Installation of direct-vent water heaters within an enclosure is not required. See Section G2406.

M2005.2.1 Water heater access. Access to water heaters that are located in an *attic* or underfloor *crawl space* is permitted to be through a closet located in a sleeping room or bathroom where *ventilation* of those spaces is in accordance with this code and the requirements of Section G2406.2.

M2005.3 Electric water heaters. Electric water heaters shall be installed in accordance with the applicable provisions of Chapters 34 through 43 the *North Carolina Electrical Code*.

M2005.4 ~~(1002.3)~~ Supplemental water-heating devices. Potable water-heating devices that use refrigerant-to-water heat exchangers shall be *approved* and installed in accordance with the manufacturer's instructions.

M2006.1 ~~(916.1)~~ General. Pool and spa heaters shall be installed in accordance with the manufacturer's installation instructions. Oil-fired pool heaters shall comply with UL 726. Electric pool and spa heaters shall comply with UL 1261. Pool and spa heat pump water heaters shall comply with UL 1995, UL/CSA/ANCE 60335-2-40 or CSA C22.2 No. 236.

Exception: Portable residential spas and portable residential exercise spas shall comply with UL 1563 or CSA C22.2 No. 218.1.

M2006.3 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.

User notes:

About this chapter: Chapter 21 is specific to hydronic piping, which includes steam, hot water and ground-source heat-pump system loop piping. This chapter addresses piping materials, joining methods, support, protection of the structure, testing, protection of potable water and general installation requirements.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page vi.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M2101.2 (1206.2) System drain down. Hydronic piping systems shall be installed to permit draining of the system. Where the system drains to the plumbing drainage system, the installation shall conform to the requirements of Chapters 25 through 32 of this code.

Exception: The buried portions of systems embedded underground or under floors.

M2101.3 (1206.3) Protection of potable water. The potable water system shall be protected from backflow in accordance with the provisions listed in Section P2902.

M2101.4 (1206.4) Pipe penetrations. Openings for pipe penetrations in walls, floors or ceilings shall be larger than the penetrating pipe. Openings through concrete or masonry building elements shall be sleeved. The annular space between the outside of a pipe and the inside of a pipe sleeve or between the outside of a pipe and an opening in a building envelope wall, floor, or ceiling assembly penetrated by a pipe shall be sealed with caulking material or foam sealant or closed with a gasketing system. The caulking material, foam sealant or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve and building materials in contact with the sealing materials. Annular spaces created by pipes penetrating fire-resistance-rated assemblies or membranes of such assemblies shall be sealed or closed in accordance with the building portion of this code.

M2101.5 (1206.6) Contact with building material. A hydronic piping system shall not be in direct contact with any building material that causes the piping material to degrade or corrode.

M2101.6 Drilling and notching. Wood-framed structural members shall be drilled, notched or altered in accordance with the provisions of Sections R502.8, R602.6, R602.6.1 and R802.7. Holes in load-bearing members of cold-formed steel *light-frame construction* shall not be permitted unless prescribed by a registered design professional only in accordance with Sections R505.2.6, R603.2.6 and R804.2.6. In accordance with the provisions of Sections R505.3.5, R603.3.4 and R804.3.3, eCutting and notching of flanges and lips of load-bearing members of cold-formed steel *light-frame construction* shall not be permitted unless prescribed by a registered design professional. Structural insulated panels (SIPs) shall be drilled and notched or altered in accordance with the provisions of Section R610.7.

M2101.9 (305.4) Piping support. Hangers and supports shall be of material of sufficient strength to support the piping, and shall be fabricated from materials compatible with the piping material. Piping shall be supported at intervals not exceeding the spacing specified in Table M2101.9.

**TABLE M2101.9
HANGER SPACING INTERVALS**

PIPING MATERIAL	MAXIMUM HORIZONTAL SPACING (feet)	MAXIMUM VERTICAL SPACING (feet)
ABS	4	10 ^a
CPVC ≤ 1-inch pipe or tubing	3	5 ^a
CPVC ≥ 1 ¹ / ₄ inches	4	10 ^a

Copper or copper alloy pipe	12	10
Copper or copper alloy tubing	6	10
PB pipe or tubing	2.67	4
PE pipe or tubing	2.67	4
PE-RT ≤ 1 inch	2.67	10 ^a
PE-RT ≥ 1 1/4 inches	4	10 ^a
PEX tubing ≤ 1 inch	2.67	4
PEX tubing ≥ 1 1/4 inches	4	10 ^a
PP < 1-inch pipe or tubing	2.67	4
PP > 1 1/4 inches	4	10 ^a
PVC	4	10 ^a
Steel pipe	12	15
Steel tubing	8	10

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

a. For sizes 2 inches and smaller, a guide shall be installed midway between required vertical supports. Such guides shall prevent pipe movement in a direction perpendicular to the axis of the pipe.

M2101.10 Tests. Hydronic piping systems shall be tested hydrostatically at a pressure of one and one-half times the maximum system design pressure, but not less than 100 pounds per square inch (689 kPa). The duration of each test shall be not less than 15 minutes.

Exception: For PEX piping systems, testing with a compressed gas shall be an alternative to hydrostatic testing where compressed air or other gas pressure testing is specifically authorized by all of the manufacturers' instructions for the PEX pipe and fittings products installed at the time the system is being tested, and compressed air or other gas testing is not otherwise prohibited by applicable codes, laws, or regulations outside of this code.

M2101.10.1 (1201.4) Test gauges. Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 pounds per square inch (psi) (69 kPa) or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.
2. Tests requiring a pressure of greater than 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall utilize a testing gauge having increments of 1 psi (6.9 kPa) or less.
3. Tests requiring a pressure of greater than 100 psi (689 kPa) shall utilize a testing gauge having increments of 2 psi (14 kPa) or less.

M2101.10.2 (1209.2) Pressurizing during installation. 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.

M2101.12 (1206.4) Pipe penetrations. Openings for pipe penetrations in walls, floors or 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 *International Building Code*.

M2101.13 (1206.5) Clearance to combustibles. A pipe in a hydronic piping system in which the exterior temperature exceeds 250°F (121°C) shall have a minimum clearance of 1 inch (25 mm) to combustible materials.

M2101.14 (1206.6) Contact with building material. A hydronic piping system shall not be in direct contact with

building materials that cause the piping material to degrade or corrode, or that interfere with the operation of the system.

M2101.17 (1206.9) 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 to avoid structural stresses or strains within building components.

M2101.17.1 (1206.9.1) 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.

M2101.11 Used materials. Used pipe, fittings, valves and other materials shall not be reused in hydronic systems.

M2101.12 Material rating. Pipe and tubing shall be rated for the operating temperature and pressure of the system. Fittings shall be suitable for the pressure applications and recommended by the manufacturer for use with the pipe and tubing material installed. Where used underground, materials shall be suitable for burial.

M2101.13 Joints and connections. Joints and connections shall be of an *approved* type. Joints and connections shall be tight for the pressure of the system. Joints used underground shall be *approved* for such applications.

M2101.13.1 Joints between different piping materials. Joints between different piping materials shall be made with *approved* transition fittings.

M2101.14 Preparation of pipe ends. Pipe shall be cut square, reamed and chamfered, and shall be free from burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

M2101.15 Joint preparation and installation. Where required by Sections M2101.16 through M2101.26, the preparation and installation of brazed, mechanical, soldered, solvent-cemented, threaded, welded and thermoplastic-welded joints shall comply with Sections M2101.15.1 and M2101.15.29.

M21021.15.1 (1203.3.1) Brazed joints. Joint surfaces shall be cleaned. An *approved* flux shall be applied where required. The joint shall be brazed with a filler metal conforming to AWS A5.8.

M2101.15.42 Mechanical joints. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M21021.15.3 (1203.3.3) Soldered joints. Joint surfaces shall be cleaned. Solder joints shall be made in accordance with ASTM B828. Cut tube ends shall be reamed to the full inside diameter of the tube end. A flux conforming to ASTM B813 shall be applied. The joint shall be soldered with a solder conforming to ASTM B32.

M21021.15.4 (1203.3.4) Solvent-cemented joints. Joint surfaces shall be clean and free of moisture. An *approved* primer shall be applied to CPVC and PVC pipe-joint surfaces. Joints shall be made while the cement is wet. Solvent cement conforming to the following standards shall be applied to all joint surfaces:

1. ASTM D2235 for ABS joints.
2. ASTM F493 for CPVC joints.
3. ASTM D2564 for PVC joints.

CPVC joints shall be made in accordance with ASTM D2846.

Exception: For CPVC pipe joint connections, a primer is not required where all of the following conditions apply:

1. The solvent cement used is third-party certified as conforming to ASTM F493.
2. The solvent cement is yellow in color.
3. The solvent cement is used only for joining 1/2-inch (12.7 mm) through 2-inch (51 mm) diameter CPVC pipe and fittings.
4. The CPVC pipe and fittings are manufactured in accordance with ASTM D2846.

M2101.165.45 Threaded joints. Threads shall conform to ASME B1.20.1 The pipe shall be Schedule 80, 40 or heavier plastic pipe and 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.

M21021.15.6 (1203.3.6) Welded joints. Joint surfaces shall be cleaned by an *approved* procedure. Joints shall be welded with an *approved* filler metal.

M21021.15.7 (1203.3.7) Grooved and shouldered mechanical joints. Grooved and shouldered mechanical joints shall conform to the requirements of ASTM F1476 and shall be installed in accordance with the manufacturer's instructions.

M21021.15.8 (4203.3.8) Mechanically formed tee fittings. Mechanically extracted outlets shall have a height not less than three times the thickness of the branch tube wall.

M21021.15.8.1 (4203.3.8.1) Full flow assurance. Branch tubes shall not restrict the flow in the run tube. A dimple/depth stop shall be formed in the branch tube to ensure that penetration into the outlet is of the correct depth. For inspection purposes, a second dimple shall be placed 1/4 inch (6.4 mm) above the first dimple. Dimples shall be aligned with the tube run.

M21021.15.8.2 (4203.3.8.2) Brazed joints. Mechanically formed tee fittings shall be brazed in accordance with Section M21021.15.1.

M2101.15.29 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 instructions.

M2101.16 ABS, CPVC and PVC plastic pipe. Joints between CPVC plastic pipe or fittings shall be solvent cemented in accordance with Section P2906.9.1.2 M2101.15.4. Threaded joints between fittings and CPVC plastic pipe shall be in accordance with Section M2101.165.4.5.

M21021.517 (4203.7) Copper or copper-alloy pipe. Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, soldered, threaded or welded joints conforming to Section M21021.15.

M21021.618 (4203.8) Copper or copper-alloy tubing. Joints between copper or copper-alloy tubing or fittings shall be brazed, mechanical or soldered joints conforming to Section M21021.15, flared joints conforming to Section M21021.618.1, push-fit joints conforming to Section M21021.618.2 or *press-type connect* joints conforming to Section M21021.618.3.

M21021.618.1 (4203.8.1) Flared joints. Flared joints shall be made by a tool designed for that operation.

M21021.618.2 (4203.8.2) Push-fit joints. Push-fit joints shall be installed in accordance with the manufacturer's instructions.

M21021.618.3 (4203.8.3) Press-connect joints. *Press-connect joints* shall be installed in accordance with the manufacturer's instructions.

M2101.179 Cross-linked polyethylene (PEX) plastic tubing. Joints between cross-linked polyethylene plastic tubing and fittings shall comply with Sections M2101.179.1 and M2101.179.2. Mechanical joints shall comply with Section M2101.15.4.2.

M2101.179.1 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.

M2101.179.2 Plastic-to-metal. Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to plastic pipe or tubing.

M21021.4620 (4203.18) Cross-linked polyethylene/aluminum/crosslinked polyethylene (PEX-AL-PEX) pressure pipe. Joints between cross-linked polyethylene/aluminum/crosslinked polyethylene pressure pipe and fittings shall conform to Sections M21021.4620.1 and M21021.4620.2. Mechanical joints shall comply with Section M21021.15.2.

M21021.4620.1 (4203.18.1) 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.

M21021.4620.2 (4203.18.2) PEX-AL-PEX-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 PEX-AL-PEX pipe.

M2101.4821 Polyethylene plastic pipe and tubing. Joints between polyethylene plastic pipe and tubing or fittings for systems shall be heat-fusion joints complying with Section M2101.4821.1, electrofusion joints complying with Section M2101.4821.2, or stab-type insertion joints complying with Section M2101.4821.3.

M2101.4821.1 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 from moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

M2101.4821.2 Electrofusion joints. Joints shall be of the electrofusion type. Joint surfaces shall be clean and free from 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 remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

M2101.4821.3 Stab-type insert fittings. Joint surfaces shall be clean and free from moisture. Pipe ends shall be chamfered and inserted into the fittings to full depth. Fittings shall be manufactured in accordance with ASTM F1924.

M21021.4522 (4203.17) Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe. Joints between polyethylene/aluminum/polyethylene pressure pipe and fittings shall conform to Sections M21021.4522.1 and M21021.4522.2. Mechanical joints shall comply with Section M21021.15.2.

M21021.4522.1 (4203.17.1) 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.

M21021.4522.2 (4203.17.2) PE-AL-PE-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-AL-PE pipe.

M2101.4923 Polypropylene (PP) plastic. Joints between PP plastic pipe and fittings shall comply with Sections M2101.4923.1 and M2101.4923.2.

M2101.4923.1 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 remain undisturbed until cool. Joints shall be made in accordance with ASTM F2389.

M2101.4923.2 Mechanical and compression sleeve joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer's instructions.

M2101.204 Raised temperature polyethylene (PE-RT) plastic tubing. Joints between raised temperature polyethylene tubing and fittings shall comply with Sections M2101.204.1 through M2101.204.4. Mechanical joints shall comply with Section M2101.15.4.2.

M2101.204.1 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.

M2101.204.2 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 or tubing.

M2101.204.3 Heat-fusion joints. Heat-fusion joints shall be of the socket-fusion, saddle-fusion or butt-fusion type, and shall be joined in accordance with ASTM D2657. Joint surfaces shall be clean and free from moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

M2101.204.4 Electrofusion joints. Joints shall be of the electrofusion type. Joint surfaces shall be clean and free from moisture and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

~~**M2101.21 PVC plastic pipe.** Joints between PVC plastic pipe or fittings shall be solvent cemented in accordance with Section P2906.9.1.4. Threaded joints between fittings and PVC plastic pipe shall be in accordance with Section M2101.16.1.~~

M21021.4425 (4203.13) Steel pipe. Joints between steel pipe or fittings shall be mechanical joints that are made with an *approved* elastomeric seal, or shall be brazed, threaded or welded joints conforming to Section M21021.15.

M21021.426 (4203.14) Steel tubing. Joints between steel tubing or fittings shall be mechanical or welded joints conforming to Section M21021.15.

M2101.227 Shutoff valves. Shutoff valves shall be installed in ground-source loop piping systems in the locations indicated in Sections M2101.227.1 through M2101.227.6.

M2101.227.1 Heat exchangers. Shutoff valves shall be installed on the supply and return sides of a heat exchanger.

Exception: Shutoff valves shall not be required where heat exchangers are integral with a boiler or are a component of a manufacturer's boiler and heat exchanger packaged unit and are capable of being isolated from the hydronic system by the supply and return valves required by Section M2001.3.

M2101.227.2 Central systems. Shutoff valves shall be installed on the building supply and return of a central utility system.

M2101.227.3 Pressure vessels. Shutoff valves shall be installed on the connection to any pressure vessel.

M2101.227.4 Pressure-reducing valves. Shutoff valves shall be installed on both sides of a pressure-reducing valve.

M2101.227.5 Equipment and appliances. Shutoff valves shall be installed on connections to mechanical equipment and *appliances*. This requirement does not apply to components of ground-source loop systems such as pumps, air separators, metering devices, and similar equipment.

M2101.227.6 Expansion tanks. Shutoff valves shall be installed at connections to nondiaphragm-type expansion tanks.

M2101.238 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. The valve shall be installed in accordance with Section M2002.

M2101.249 Installation. Piping, valves, fittings and connections shall be installed in accordance with the manufacturer's instructions.

M2101.25 Protection of potable water. Where hydronic systems have a connection to a potable water supply, the potable water system shall be protected from backflow in accordance with Section P2902.

M2101.26 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 Section P2606.1.

M2101.2730 Clearance from combustibles. A pipe in a piping system having an exterior surface temperature exceeding 250°F (121°C) shall have a clearance of not less than 1 inch (25 mm) from *combustible materials*.

M2101.28 Contact with building material. A piping system shall not be in direct contact with building materials that cause the piping or fitting material to degrade or corrode, or that interfere with the operation of the system.

M2101.2931 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.

M2101.2931.1 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.

M2101.3032 Chemical compatibility. Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings and mechanical systems.

M2101.343 Makeup water. The transfer fluid shall be compatible with the makeup water supplied to the system.

M2101.4134 (1206.11) Condensation. Provisions shall be made to prevent the formation of condensation on the exterior of hydronic piping. Hydronic piping shall be insulated per the mechanical system piping insulation requirements of Chapter 11 of this code.

M2101.4535 (1206.7) Water hammer. The flow velocity of the hydronic piping system shall be controlled to reduce the possibility of water hammer. Where a quick-closing valve creates water hammer, an *approved* water-hammer arrestor shall be installed. The arrestor shall be located within a range as specified by the manufacturer of the quick-closing valve.

M2101.4636 (1206.8) Steam piping pitch. Steam piping shall be installed to drain to the boiler or the steam trap. Steam systems shall not have drip pockets that reduce the capacity of the steam piping.

SECTION M2102

BASEBOARD CONVECTORS JOINTS AND CONNECTIONS

M2102.1 General. Baseboard convectors shall be installed in accordance with the manufacturer's instructions. Convectors shall be supported independently of the hydronic piping.

M2102.1 (1203.3) Joint preparation and installation. Joints and connections shall be of an *approved* type. Joints and connections shall be tight for the pressure of the hydronic system. Joints between different piping materials shall be made with *approved* adapter fittings. Pipe shall be cut square, reamed and chamfered, and shall be free of burrs and obstructions. Pipe ends shall have full bore openings and shall not be undercut.

Where required by Sections M2102.2 through M2102.12, the preparation and installation of brazed, mechanical, soldered, solvent cemented, threaded and welded joints shall comply with Sections M2102.1.1 through M2102.1.8.

M2102.1.2 (1203.3.2) Mechanical joints. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M2102.1.5 (1203.3.5) Threaded joints. Threads shall conform to 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.

M2102.2 (1203.4) ABS plastic pipe. Joints between ABS plastic pipe or fittings shall be solvent cemented or threaded joints conforming to Section M2102.1.

M2102.3 (1203.5) Brass pipe. Joints between brass pipe or fittings shall be brazed, mechanical, threaded or welded joints conforming to Section M2102.1.

M2102.4 (1203.6) Brass tubing. Joints between brass tubing or fittings shall be brazed, mechanical or soldered joints conforming to Section M2102.1.

M2102.7 (1203.9) CPVC plastic pipe. Joints between CPVC plastic pipe or fittings shall be solvent cemented or threaded joints conforming to Section M2102.1.

M2102.8 (1203.10) Polybutylene plastic pipe and tubing. Joints between polybutylene plastic pipe and tubing or fittings shall be mechanical joints conforming to Section M2102.1 or heat fusion joints conforming to Section M2102.8.1.

M2102.8.1 (1203.10.1) Heat fusion joints. Joints shall be of the socket fusion or butt fusion type. 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. Joints shall be made in accordance with ASTM D3309.

M2102.9 (1203.11) Cross-linked polyethylene (PEX) plastic tubing. Joints between cross-linked polyethylene plastic tubing and fittings shall conform to Sections M2102.9.1 and M2102.9.2. Mechanical joints shall conform to Section M2102.1.

M2102.9.1 (1203.11.1) 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.

M2102.9.2 (1203.11.2) 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.

M2102.10 (1203.12) PVC plastic pipe. Joints between PVC plastic pipe and fittings shall be solvent cemented or threaded joints conforming to Section M2102.1.

M2102.13 (1203.15) Polypropylene (PP) plastic. Joints between PP plastic pipe and fittings shall comply with Sections M2102.13.1 and M2102.13.2.

M2102.13.1 (1203.15.1) Heat fusion joints. Heat fusion joints for polypropylene (PP) pipe and tubing joints shall be installed with socket type heat fused polypropylene fittings, electro fusion 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.

M2102.13.2 (1203.15.2) Mechanical and compression sleeve joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer's instructions.

M2102.14 (1203.16) Raised temperature polyethylene (PE-RT) plastic tubing. Joints between raised temperature polyethylene tubing and fittings shall conform to Sections M2102.14.1 and M2102.14.2. Mechanical joints shall conform to Section M2102.1.

M2102.14.1 (1203.16.1) 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.

M2102.14.2 (1203.16.2) 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.

M2103.1 Piping materials. Piping for embedment in concrete or gypsum materials shall be standard-weight steel pipe, copper and copper-alloy pipe and tubing, cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure pipe, chlorinated polyvinyl chloride (CPVC), cross-linked polyethylene (PEX) tubing, polyethylene of raised temperature (PE-RT) or polypropylene (PP) with a rating of not less than 80 pounds per square inch at 180°F (552 kPa at 82°C).

M2103.2 Thermal barrier required. Radiant floor heating systems shall have a thermal barrier in accordance with Sections M2103.2.1 and M2103.2.2. Insulation *R*-values for slab-on-grade and suspended floor installations shall be in accordance with Chapter 11.

Exception: Insulation shall not be required in engineered systems where it can be demonstrated that the insulation will decrease the efficiency or have a negative effect on the installation.

M2103.2.1 Thermal break required. A thermal break consisting of asphalt expansion joint materials or similar insulating materials shall be provided at a point where a heated slab meets a foundation wall or other conductive slab.

M2103.2.2 Thermal barrier material marking. Insulating materials used in thermal barriers shall be installed so that the manufacturer's *R*-value mark is readily observable upon inspection.

M2103.3 Piping joints. Copper and copper-alloy systems shall be soldered, brazed, or press connected. Soldering shall be in accordance with ASTM B828. Fluxes for soldering shall be in accordance with ASTM B813. Brazing fluxes shall be in accordance with AWS A5.31. Press-connect joints shall be in accordance with ASME B16.51. Piping joints that are embedded shall be installed in accordance with the following requirements:

1. Steel pipe joints shall be welded.
2. Copper tubing shall be joined by brazing complying with Section P3003.6.1. All joint surfaces shall be cleaned. An approved flux shall be applied where required. Brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys filler metal shall be in accordance with AWS A5.8.
3. Polybutylene pipe and tubing joints shall be installed with socket type heat fused polybutylene fittings.
43. CPVC tubing shall be joined using solvent cement joints.
54. Polypropylene pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings.
65. Cross-linked polyethylene (PEX) tubing shall be joined using cold expansion, insert or compression fittings.
76. Raised temperature polyethylene (PE-RT) tubing shall be joined using insert or compression fittings.

~~Deleted.~~

M2103.4 Testing. Piping or tubing to be embedded shall be tested by applying a hydrostatic pressure of not less than 100 psi (690 kPa). The pressure shall be maintained for 30 minutes, during which the joints shall be visually inspected for leaks. ~~Deleted.~~

M2104.2 Piping joints. Piping joints that are embedded, other than those in Section M2103.3, shall comply with the following requirements:

1. Cross-linked polyethylene (PEX) tubing shall be installed in accordance with the manufacturer's instructions.
2. Polyethylene tubing shall be installed with heat-fusion joints.
3. Polypropylene (PP) tubing shall be installed in accordance with the manufacturer's instructions.
4. Raised temperature polyethylene (PE-RT) shall be installed in accordance with the manufacturer's instructions.

M2104.3 Raised temperature polyethylene (PE-RT) plastic tubing. Joints between raised temperature polyethylene tubing and fittings shall conform to Sections M2104.3.1 through M2104.3.3. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M2104.4 Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe. Joints between polyethylene/aluminum/polyethylene pressure pipe and fittings shall conform to Sections M2104.4.1 and M2104.4.2. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M2104.4.2 PE-AL-PE-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-AL-PE pipe.

M2105.1 (1210.4) Plastic ground-source heat-pump loop piping. Plastic piping and tubing material used in water-based ground-source heat-pump ground-loop systems shall conform to the standards specified in this section.

M2105.2 (1210.2) Used materials. Reused pipe, fittings, valves, and other materials shall not be used in ground-source heat-pump loop systems.

M2105.3 (1210.3) Material rating. Pipe and tubing shall be rated for the operating temperature and pressure of the ground-source heat-pump loop system. Fittings shall be suitable for the pressure applications and recommended by the manufacturer for installation with the pipe and tubing material installed. Where used underground, materials shall be suitable for burial.

M2105.4 (1210.4) Piping and tubing materials standards. Ground-source heat-pump ground-loop pipe and tubing shall conform to the standards listed in Table M2105.4.

M2105.5 (1210.5) Fittings. Ground-source heat-pump pipe fittings shall be *approved* for installation with the piping materials to be installed, shall conform to the standards listed in Table M2105.5 and, where installed underground, shall be suitable for burial.

M2105.6 (1210.6) Joints and connections. 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 used underground shall be *approved* for such applications.

M2105.6.1 (1210.6.1) Joints between different piping materials. Joints between different piping materials shall be made with *approved* transition fittings.

M2105.7 (1210.6.2) Preparation of pipe ends. Pipe shall be cut *square and* shall be free of burrs and obstructions. Pipe ends shall have full-bore openings and shall *be prepared in accordance with the pipe manufacturer's instructions.*

M2105.8 (1210.6.3) Joint preparation and installation. Where required by Sections M2105.9 through M2105.11, the preparation and installation of mechanical and thermoplastic-welded joints shall comply with Sections M2105.8.1 and M2105.8.2.

M2105.8.1 (1210.6.3.1) Mechanical joints. Mechanical joints shall be installed in accordance with the manufacturer's instructions.

M2105.8.2 (1210.6.3.2) 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 instructions.

M2105.9 (1210.6.4) CPVC plastic pipe. Joints between CPVC plastic pipe or fittings shall be solvent-cemented in accordance with Section ~~P2906.9.1.2~~M2101.15.4. Threaded joints between fittings and CPVC plastic pipe shall be in accordance with Section M2105.9.1.

M2105.10 (1210.6.5) Cross-linked polyethylene (PEX) plastic tubing. Joints between cross-linked polyethylene plastic tubing and fittings shall comply with Sections M2105.10.1 and M2105.10.2. Mechanical joints shall comply with Section M2105.8.1.

M2105.10.1 (1210.6.5.1) 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.

M2105.10.2 (1210.6.5.2) Plastic-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 plastic pipe or tubing.

M2105.11 (1210.6.6) Polyethylene plastic pipe and tubing. Joints between polyethylene plastic pipe and tubing or fittings for ground-source heat-pump loop systems shall be heat-fusion joints complying with Section M2105.11.1, electrofusion joints complying with Section M2105.11.2, or stab-type insertion joints complying with Section M2105.11.3.

M2105.11.1 (1210.6.6.1) 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 *from* moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall *remain* undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

M2105.11.2 (1210.6.6.1) Electrofusion joints. Joints shall be of the electrofusion type. Joint surfaces shall be clean and free from 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 remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

M2105.11.3 (1210.6.6.3) Stab-type insert fittings. Joint surfaces shall be clean and free from moisture. Pipe ends shall be chamfered and inserted into the fittings to full depth. Fittings shall be manufactured in accordance with ASTM F1924.

M2105.12 (1210.6.7) Polypropylene (PP) plastic. Joints between PP plastic pipe and fittings shall comply with Sections M2105.12.1 and M2105.12.2.

M2105.12.1 (1210.6.7.1) 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 remain undisturbed until cool. Joints shall be made in accordance with ASTM F2389.

M2105.12.2 (1210.6.7.2) Mechanical and compression sleeve joints. Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer's instructions.

M2105.13 (1210.6.8) Raised temperature polyethylene (PE-RT) plastic tubing. Joints between raised temperature polyethylene tubing and fittings shall comply with Sections M2105.13.1 through M2105.13.4. Mechanical joints shall comply with Section M2105.8.1.

M2105.13.1 (1210.6.8.1) 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.

M2105.13.2 (1210.6.8.2) 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 or tubing.

M2105.13.3 Heat-fusion joints. Heat-fusion joints shall be of the socket-fusion, saddle-fusion or butt-fusion type, and shall be joined in accordance with ASTM D2657. Joint surfaces shall be clean and free from moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D2683 or ASTM D3261.

M2105.13.4 Electrofusion joints. Joints shall be of the electrofusion type. Joint surfaces shall be clean and free from moisture and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer and joined. The joint shall remain undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F1055.

M2105.14 (1210.6.9) PVC plastic pipe. Joints between PVC plastic pipe or fittings shall be solvent-cemented in accordance with Section P2906.9.1.4 M2101.15.4. Threaded joints between fittings and PVC plastic pipe shall be in accordance with Section M2105.9.1.

M2105.15 (1210.7) Shutoff valves. Shutoff valves shall be installed in ground-source loop piping systems in the locations indicated in Sections M2105.15.1 through M2105.15.6.

M2105.15.5 Equipment and appliances. Shutoff valves shall be installed on connections to mechanical equipment and appliances. This requirement does not apply to components of ground-source loop systems such as pumps, air separators, metering devices, and similar equipment.

M2105.16 (1210.7.7) 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. The valve shall be installed in accordance with Section M2002.

M2105.17 (1210.8) Installation. Piping, valves, fittings, and connections shall be installed in accordance with the manufacturer's instructions.

M2105.18 (1210.8.1) 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 from backflow in accordance with Section P2902.

M2105.19 (1210.8.2) 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 Section P2606.1. The annular space between the outside of a pipe and the inside of a pipe sleeve or between the outside of a pipe and an opening in a building

envelope wall, floor, or ceiling assembly penetrated by a pipe shall be sealed with caulking material or foam sealant or closed with a gasketing system. The caulking material, foam sealant or gasketing system shall be designed for the conditions at the penetration location and shall be compatible with the pipe, sleeve and building materials in contact with the sealing materials. Annular spaces created by pipes penetrating fire-resistance-rated assemblies or membranes of such assemblies shall be sealed or closed in accordance with the building portion of this code.

M2105.20 (1210.8.3) 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 mm) from combustible materials.

M2105.21 (1210.8.4) 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 interfere with the operation of the system.

M2105.22 (1210.8.5) 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.

M2105.23 (1210.8.7) Pipe support. Pipe shall be supported in accordance with Section M2101.9.

M2105.24 (1210.8.8) 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.

M2105.25 (1210.8.9) 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 state the following words: "GROUND-SOURCE HEAT-PUMP LOOP SYSTEM." The marking shall indicate if antifreeze is used in the system and shall indicate the chemicals by name and concentration.

M2105.26 (1210.8.10) Chemical compatibility. Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings and mechanical systems.

M2105.27 (1210.9) Makeup water. The transfer fluid shall be compatible with the makeup water supplied to the system.

M2105.28 (1210.10) 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 without 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. If 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.

M2105.29 (1210.11) Embedded piping. 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.

SECTION M2106
BASEBOARD CONVECTORS

M2106.1 General. Baseboard convectors shall be installed in accordance with the manufacturer's instructions. Convectors shall be supported independently of the hydronic piping.

TABLE M2101.1 (1202.4)
HYDRONIC PIPING AND FITTING MATERIALS

MATERIAL	USE CODE ^a	STANDARD ^b	JOINTS	NOTES
Acrylonitrile butadiene styrene (ABS) plastic pipe	1, 5	ASTM D1527, ASTM F2806, ASTM F2969	Solvent cement joints, Threaded, if permitted by the manufacturer.	—

Chlorinated poly (vinyl chloride) (CPVC) pipe and tubing	1, 2, 3	ASTM D2846	Solvent cement joints, compression joints and threaded adapters	—
Copper and copper-alloy tubing (Type K, L or M)	1, 2	ASME B16.51, ASTM B75, ASTM B88, ASTM B135, ASTM B251, ASTM B306	Brazed, soldered, press-connected and flared mechanical fittings	Joints embedded in concrete shall be brazed
Cross-linked polyethylene (PEX)	1, 2, 3	ASTM F876; ASTM F3253	(See PEX fittings)	Install in accordance with manufacturer's instructions
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure pipe	1, 2	ASTM F1281 or CAN/CSA B137.10	Mechanical, crimp/insert	Install in accordance with manufacturer's instructions
PEX fittings	—	ASTM F877, ASTM F1807, ASTM F1960, ASTM F2098, ASTM F2159, ASTM F2735, ASTM F3253	Copper crimp/insert fittings, cold expansion fittings, stainless steel clamp, insert fittings	Install in accordance with manufacturer's instructions
Polybutylene (PB) pipe and tubing	1, 2, 3	ASTM D3309	Heat fusion, crimp/insert and compression	Joints in concrete shall be heat fused
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	1, 2, 3	ASTM F1282, CSA B137.9	Mechanical, crimp/insert	—
Polypropylene (PP)	1, 2, 3	ISO 15874, ASTM F2389	Heat-fusion joints, mechanical fittings, threaded adapters, compression joints	—
Raised temperature polyethylene (PE-RT)	1, 2, 3	ASTM F2623, ASTM F2769, CSA B137.18	Copper crimp/insert fitting, stainless steel clamp, insert fittings	—
Raised temperature polyethylene (PE-RT) fittings	1, 2, 3	ASTM D3261, ASTM F1807, ASTM F2098, ASTM F2159, ASTM F2735, ASTM F2769, CSA B137.18	Copper crimp/insert fitting, stainless steel clamp, insert fittings	—
Steel pipe	1, 2	ASTM A53, ASTM A106	Brazed, welded, threaded, flanged and mechanical fittings	Joints in concrete shall be welded. Galvanized pipe shall not be welded or brazed.
Steel tubing	1	ASTM A254	Mechanical fittings, welded	—

For SI: °C = [(°F) – 32]/1.8.

a. Use code:

1. Above ground.

2. Embedded in radiant systems.
 3. Temperatures below 180°F only.
 4. Low-temperature (below 130°F) applications only.
 5. Temperatures below 160°F only.
- b. Standards as listed in Chapter 44.

**TABLE M2105.4
GROUND-SOURCE LOOP PIPE**

MATERIAL	STANDARD
Chlorinated polyvinyl chloride (CPVC)	ASTM D2846; ASTM F437; ASTM F438; ASTM F439; ASTM F441; ASTM F442; CSA B137.6
Cross-linked polyethylene (PEX)	ASTM F876; CSA B137.5; ANSI/CSA/IGSHPA C448; NSF 358-3
High-density polyethylene (HDPE)	ASTM D2737; ASTM D3035; ASTM F714; AWWA C901; CSA B137.1; ANSI/CSA/IGSHPA C448; NSF 358-1
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F1282; AWWA C903; CSA B137.9
Polypropylene (PP-R)	ASTM F2389; CSA B137.11; NSF 358-2
Polyvinyl chloride (PVC)	ASTM D1785; ASTM D2241; CSA B137.3
Raised temperature polyethylene (PE-RT)	ASTM F2623; ASTM F2769; CSA B137.18; ANSI/CSA/IGSHPA C448; NSF 358-4

**TABLE M2105.5
GROUND-SOURCE LOOP PIPE FITTINGS**

PIPE MATERIAL	STANDARD
Chlorinated polyvinyl chloride (CPVC)	ASTM D2846; ASTM F437; ASTM F438; ASTM F439; ASTM F1970; CSA B137.6
Cross-linked polyethylene (PEX)	ASTM F877; ASTM F1807; ASTM F1960; ASTM F2080; ASTM F2159; ASTM F2434; CSA B137.5; ANSI/CSA/IGSHPA C448; NSF 358-3
High-density polyethylene (HDPE)	ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1; ANSI/CSA/IGSHPA C448; NSF 358-1
Polyethylene/aluminum/polyethylene (PE-AL-PE)	ASTM F1282; ASTM F2434; CSA B137.9
Polypropylene (PP-R)	ASTM F2389; CSA B137.11; NSF 358-2
Polyvinyl chloride (PVC)	ASTM D2464; ASTM D2466; ASTM D2467; ASTM F1970; CSA B137.2; CSA B137.3
Raised temperature polyethylene (PE-RT)	ASTM D2683; ASTM D3261; ASTM F1055; ASTM F1807; ASTM F2098; ASTM F2159; ASTM F2735; ASTM F2769; CSA B137.1; CSA B137.18; ANSI/CSA/IGSHPA C448; NSF 358-4

CHAPTER 22

SPECIAL FUEL OIL PIPING AND STORAGE SYSTEMS

User notes:

— **About this chapter:** Chapter 22 addresses fuel oil piping and storage related to oil-fired heating appliances. Materials, joining methods, tanks, pumps, valves and installation of such are covered.

— **Code development reminder:** Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the *North Carolina Mechanical Code* and has been modified where necessary to conform to the scope of application of the *North Carolina Residential Code for One and Two Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *North Carolina Mechanical Code*.

M2201.1 Materials. Supply tanks shall be *listed* and *labeled* and shall conform to UL 58 for underground tanks, UL 142 for above-ground tanks, and UL 80 for indoor tanks.

M2201.2 (1309.2) Above-ground tanks. The maximum amount of fuel oil stored above ground or inside of a building shall be 660 gallons (2498 L). The supply tank shall be supported on rigid noncombustible supports to prevent settling or shifting.

Exception: The storage of fuel oil, used for space or water heating, above ground or inside buildings in quantities exceeding 660 gallons (2498 L) shall comply with NFPA 31.

M2201.2.1 (1309.2.1) Tanks within buildings. Supply tanks for use inside of buildings shall be of such size and shape to permit installation and removal from *dwellings* as whole units. Supply tanks larger than 10 gallons (38 L) shall be placed not less than 5 feet (1524 mm) from any fire or flame either within or external to any fuel-burning *appliance*.

M2201.2.2 (1309.2.2) Outdoor above-ground tanks. Tanks installed *outdoors*, above ground shall be *not less than* 5 feet (1524 mm) from an adjoining property line. Such tanks shall be suitably protected from the weather and from physical damage.

M2201.3 (1309.3) Underground tanks. Excavations for underground tanks shall not undermine the foundations of existing structures. The clearance from the tank to the nearest wall of a *basement*, pit or property line shall be not less than 1 foot (305 mm). Tanks shall be set on and surrounded with noncorrosive inert materials such as clean earth, sand or gravel well-tamped in place. Tanks shall be covered with not less than 1 foot (305 mm) of earth. Corrosion protection shall be provided in accordance with Section M2203.7.

M2201.4 (1309.4) Multiple tanks. Cross connection of two supply tanks shall be permitted in accordance with Section M2203.6.

M2201.5 (1309.5, 1306.3) Oil gauges. Inside tanks shall be provided with a device to indicate when the oil in the tank has reached a predetermined safe level. Glass gauges or a gauge subject to breakage that could result in the escape of oil from the tank shall not be used. Liquid-level indicating gauges shall comply with UL 180.

M2201.6 (1309.6) Flood-resistant installation. In flood hazard areas as established by Table R301.2, *underground* tanks shall be *installed in accordance with Section R322.2.4 or R322.3.10 anchored to prevent flotation, collapse and lateral movement under conditions of the base flood*. In flood hazard areas as established by Table R301.2, *above-ground* tanks shall be installed at or above the elevation required in Section R322 or shall be anchored to prevent flotation, collapse and lateral movement under conditions of the base flood. Where elevated on platforms, the platforms shall be cantilevered from or knee braced to the building or shall be supported on foundations that conform to the requirements of Section R322.

M2201.7 (1301.5) Tanks abandoned or removed. *Outdoor* above-grade fill piping shall be removed when tanks are abandoned or removed. Tank abandonment and removal shall be in accordance with the *International Fire Code*. Tank abandonment and removal shall be in accordance with Section 5704.2.13 of the *International Fire Code*.

M2202.1 Materials. Piping shall consist of steel pipe, copper and copper alloy pipe and tubing, steel tubing conforming to ASTM A539, or stainless steel tubing conforming to ASTM A254 or ASTM A269. Aluminum tubing shall not be used between the fuel-oil tank and the burner units.

M2202.2 Joints and fittings. Piping shall be connected with standard fittings compatible with the piping material. Cast iron fittings shall not be used for oil piping. Unions requiring gaskets or packings, right or left couplings, and sweat fittings employing solder having a melting point less than 1,000°F (538°C) shall not be used for oil piping. Threaded joints and connections shall be made tight with a lubricant or pipe thread compound.

M2202.3 Flexible connectors. Flexible metallic hoses shall be listed and labeled in accordance with UL 536 and shall be installed in accordance with their listing and labeling and the manufacturer's installation instructions. Connectors made from combustible materials shall not be used inside of buildings or above ground outside of buildings.

M2202.1 (1302.1) General. Piping materials shall conform to the standards cited in this section.

M2202.2 (1302.2) Rated for system. All materials shall be rated for the operating temperatures and pressures of the system, and shall be compatible with the type of liquid.

M2202.3 (1302.3) Pipe standards. Fuel oil pipe shall comply with one of the standards listed in Table M2202.3.

**TABLE M2202.3 (1302.3)
FUEL OIL PIPING AND FITTINGS**

MATERIAL	STANDARD
Copper or copper-alloy pipe and fittings	ASTM B42; ASTM B43; ASTM B302; ASTM F3226
Copper or copper-alloy tubing and fittings (Type K, L or M)	ASME B16.51; ASTM B75; ASTM B88; ASTM B280; ASTM F3226
Labeled pipe	(See Section 1302.4M2202.4)
Nonmetallic pipe	ASTM D2996
Steel and stainless steel pipe and fittings	ASTM A53; ASTM A106; ASTM A312; ASTM F3226
Steel and stainless steel tubing and fittings	ASTM A254; ASTM A269; ASTM A539; ASTM F3226

M2202.4 (1302.4) Nonmetallic pipe. Nonmetallic pipe shall be listed and labeled as being acceptable for the intended application for flammable and combustible liquids. Nonmetallic pipe shall be installed only outside outdoors, underground.

M2202.5 (1302.5) Fittings and valves. Fittings and valves shall be approved for the piping systems, and shall be compatible with, or shall be of the same material as, the pipe or tubing.

M2202.6 (1302.6) Bending of pipe. Pipe shall be approved for bending. Pipe bends shall be made with approved equipment. The bend shall not exceed the structural limitations of the pipe.

M2202.7 (1302.7) Pumps. Pumps that are not part of an appliance shall be of a positive-displacement type. The pump shall automatically shut off the supply when not in operation. Pumps shall be listed and labeled in accordance with UL 343.

M2202.8 (1302.8) Flexible connectors and hoses. Flexible connectors and hoses shall be listed and labeled in accordance with UL 536 as being acceptable for the intended application for flammable and combustible liquids.

M2202.9 Piping systems. Above-ground piping systems shall be listed and labeled in accordance with UL 1369. Underground piping systems shall be listed and labeled in accordance with UL 971A.

M2202.910 (1303.1) Approval. Joints and connections shall be approved and of a type approved for fuel-oil piping systems. Threaded joints and connections shall be made tight with suitable lubricant or pipe compound. Unions requiring gaskets or packings, right or left couplings, and sweat fittings employing solder having a melting point of less than 1,000°F (538°C) shall not be used in oil lines. Cast-iron fittings shall not be used. Joints and connections shall be tight for the pressure required by test.

M2202.910.1 (1303.1.1) Joints between different piping materials. Joints between different piping materials shall be made with approved adapter fittings. Joints between different metallic piping materials shall be made with approved dielectric fittings or brass-copper-alloy converter fittings.

M2202.1011 (1303.2) Preparation of pipe ends. Pipe shall be cut square, reamed and chamfered and be free from all burrs and obstructions. Pipe ends shall have full-bore openings and shall not be undercut.

M2202.4112 (1303.3) Joint preparation and installation. Where required by Sections M2202.4213 through M2202.18, the preparation and installation of brazed, mechanical, threaded, **press-connect** and welded joints shall comply with Sections M2202.4112.1 through M2202.4112.45.

M2202.4112.1 (1303.3.1) Brazed joints. All joint surfaces shall be cleaned. An *approved* flux shall be applied where required. The joints shall be brazed with a filler metal conforming to AWS A5.8.

M2202.4112.2 (1303.3.2) Mechanical joints. Mechanical joints shall be installed in accordance with the manufacturer's instructions. **Press connect joints shall conform to one of the standards listed in Table 1302.3.**

M2202.4112.3 (1303.3.3) Threaded joints. Threads shall conform to ASME B1.20.1. Pipe-joint compound or tape shall be applied on the male threads only.

M2202.4112.4 (1303.3.4) Welded joints. All joint surfaces shall be cleaned by an *approved* procedure. The joint shall be welded with an *approved* filler metal.

M2202.12.5 Press-connect joints. *Press-connect joints* shall be installed in accordance with the manufacturer's instructions and shall conform to one of the standards listed in Table M2203.

M2202.12 (1303.4) Brass pipe. Joints between brass pipe or fittings shall be brazed, mechanical, threaded or welded joints complying with Section M2202.11.

M2202.13 (1303.5) Brass tubing. Joints between brass tubing or fittings shall be brazed or mechanical joints complying with Section M2202.11.

M2202.4113 (1303.6) Copper or copper-alloy pipe. Joints between copper or copper-alloy pipe or fittings shall be brazed, mechanical, threaded, **press-connect** or welded joints complying with Section M2202.4112.

M2202.4514 (1303.7) Copper or copper-alloy tubing. Joints between copper or copper-alloy tubing or fittings shall be brazed, or mechanical joints complying with Section M2202.11 or flared joints. **Flared joints shall be made by a tool designed for that operation, or press-connect joints complying with Section M2202.12.**

M2202.4615 (1303.8) Nonmetallic pipe. Joints between nonmetallic pipe or fittings shall be installed in accordance with the manufacturer's instructions for the *labeled* pipe and fittings.

M2202.4716 (1303.9) Steel and stainless steel pipe. Joints between steel or stainless steel pipe or fittings shall be threaded, **press-connect** or welded joints complying with Section M2202.4112 or mechanical joints complying with Section M2202.4716.1.

M2202.4716.1 (1303.9.1) Mechanical joints. Joints shall be made with an *approved* elastomeric seal. Mechanical joints shall be installed in accordance with the manufacturer's instructions. Mechanical joints shall be installed **outside outdoors**, underground, unless otherwise *approved*.

M2202.4817 (1303.10) Steel and stainless steel tubing. Joints between steel or stainless steel tubing or fittings shall be mechanical, **press-connect** or welded joints complying with Section M2202.4112.

M2202.4918 (1303.11) Piping protection. Proper allowance shall be made for expansion, contraction, jarring and vibration. Piping other than tubing, connected to underground tanks, except straight fill lines and test wells, shall be provided with flexible connectors, or otherwise arranged to permit the tanks to settle without impairing the tightness of the piping connections.

M2203.1 General. Piping shall be installed in a manner to avoid placing stresses on the piping, and to accommodate expansion and contraction of the piping system. **Hanger spacing intervals for piping supports shall be per Table M2101.9.**

M2203.2 Supply piping. Supply piping used in the installation of oil burners and *appliances* shall be not smaller than $\frac{3}{8}$ -inch (9 mm) pipe or $\frac{3}{8}$ -inch (9 mm) outside diameter tubing. **Copper tubing and fittings shall be a minimum of Type L or heavier.** The fuel oil system shall be sized for the maximum capacity of fuel oil required. The minimum size of a supply line shall be $\frac{3}{8}$ -inch (9.5 mm) inside diameter nominal pipe or $\frac{3}{8}$ -inch (9.5 mm) outside diameter tubing. The minimum size of a return line shall be $\frac{1}{4}$ -inch (6.4 mm) inside diameter nominal pipe or $\frac{5}{16}$ -inch (7.9 mm) outside diameter tubing. Copper tubing shall have 0.035-inch (0.9 mm) nominal and 0.032-inch (0.8 mm) minimum wall thickness.

M2203.2.1 (1305.3) Supply piping installation. Supply piping shall connect to the top of the fuel oil tank. Fuel oil shall be supplied by a transfer pump or automatic pump or by other *approved* means.

Exception: This section shall not apply to inside or above-ground fuel oil tanks.

M2203.2.2 (1305.4) Return piping. Return piping shall connect to the top of the fuel oil tank. Valves shall not be installed on return piping.

M2203.2.3 (1305.5) System pressure. The system shall be designed for the maximum pressure required by the fuel-oil-burning *appliance*. Air or other gases shall not be used to pressurize tanks.

M2203.2.4 (1308.1) Testing required. Fuel oil piping shall be tested in accordance with NFPA 31.

M2203.2.4.1 (1201.4) Test gauges. Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 pounds per square inch (psi) (69 kPa) or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.
2. Tests requiring a pressure of greater than 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall utilize a testing gauge having increments of 1 psi (6.9 kPa) or less.
3. Tests requiring a pressure of greater than 100 psi (689 kPa) shall utilize a testing gauge having increments of 2 psi (14 kPa) or less.

M2203.3 (1305.6) Fill piping. Fill piping shall terminate outside of buildings at a point not less than 2 feet (610 mm) from any building opening at the same or lower level. Fill openings shall be equipped with a tight metal cover.

M2203.4 (1305.7) Vent piping. Vent piping shall be not smaller than 1¹/₄-inch (32 mm) pipe. Vent piping shall be laid to drain toward the tank without sags or traps in which the liquid can collect. Vent pipes shall not be cross connected with fill pipes, lines from burners or overflow lines from auxiliary tanks. The lower end of a vent pipe shall enter the tank through the top and shall extend into the tank not more than 1 inch (25 mm).

M2203.5 (1305.7) Vent termination. Vent piping shall terminate outside of buildings at a point not less than 2 feet (610 mm), measured vertically or horizontally, from any building opening. Outer ends of vent piping shall terminate in a weather proof cap or fitting having an unobstructed area at least equal to or greater than the cross sectional area of the vent pipe, and shall be located sufficiently above the ground to avoid being obstructed by snow and ice. Liquid fuel vent pipes shall terminate outside of buildings at a point not less than 2 feet (610 mm) measured vertically or horizontally from any building opening. Outer ends of vent pipes shall terminate in a weatherproof vent cap or fitting or be provided with a weatherproof hood. Vent caps shall have a minimum free open area equal to the cross-sectional area of the vent pipe and shall not employ screens finer than No. 4 mesh. Vent pipes shall terminate sufficiently above the ground to avoid being obstructed with snow or ice. Vent pipes from tanks containing heaters shall be extended to a location where oil vapors discharging from the vent will be readily diffused. If the static head with a vent pipe filled with oil exceeds 10 pounds per square inch (psi) (69 kPa), the tank shall be designed for the maximum static head that will be imposed.

M2203.6 (1309.7) Cross connection of tanks. Cross connection of two supply tanks, not exceeding 660 gallons (2498 L) aggregate capacity, with gravity flow from one tank to another, shall be acceptable providing that the two tanks are on the same horizontal plane.

M2203.7 (1309.8) Corrosion protection. Underground tanks and buried piping shall be protected by corrosion-resistant coatings or special alloys or fiberglass-reinforced plastic.

M2203.8 Pipe penetrations. Openings for pipe penetrations in walls, floors or 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 sealed and protected in an *approved* manner in accordance with this code.

M2204.2 Shutoff valves (1307.1) Building shutoff. A *readily accessible* manual shutoff valve shall be installed between the oil supply tank and the burner. Such valve shall be provided with *ready access*. Where the shutoff valve is installed in the discharge line of an oil pump, a pressure relief valve shall be incorporated to bypass or return surplus oil. Valves shall comply with UL 842. A shutoff valve shall be installed on the fuel-oil supply line at the entrance to the building. Inside or above-ground tanks are permitted to have valves installed at the tank. The valve shall be capable of stopping the flow of fuel oil to the building or to the *appliance* served where the valve is installed at a tank inside the building. Valves shall comply with UL 842.

M2204.3 Maximum pressure (1307.2) Appliance shutoff. Pressure at the oil supply inlet to an *appliance* shall be not greater than 3 pounds per square inch (20.7 kPa). A shutoff valve shall be installed at the connection to each *appliance* where more than one fuel-oil-burning *appliance* is installed.

M2204.4 Relief valves (1307.3) Pump relief valve. Fuel oil lines incorporating heaters shall be provided with relief valves that will discharge to a return line when excess pressure exists. A relief valve shall be installed on the pump discharge line where a valve is located downstream of the pump and the pump is capable of exceeding the pressure limitations of the fuel oil system.

M2204.5 (1307.4) Fuel-oil heater relief valve. A relief valve shall be installed on the discharge line of fuel-oil-heating *appliances*.

M2204.6 (1307.5) Relief valve operation. The relief valve shall discharge fuel oil when the pressure exceeds the limitations of the system. The discharge line shall connect to the fuel oil tank.

SECTION M2205 (1306) **OIL GAUGING**

M2205.1 (1306.1) Level indication. Tanks in which a constant oil level is not maintained by an automatic pump shall be equipped with a method of determining the oil level.

M2205.2 (1306.2) Test wells. Test wells shall not be installed inside buildings. For *outsideoutdoor* service, test wells shall be equipped with a tight metal cover designed to discourage tampering.

M2205.3 (1306.3) Inside tanks. The gauging of inside tanks by means of measuring sticks shall not be permitted. An inside tank provided with fill and vent pipes shall be provided with a device to indicate either visually or audibly at the fill point when the oil in the tank has reached a predetermined safe level.

M2205.4 (1306.4) Gauging devices. Gauging devices such as liquid level indicators or signals shall be designed and installed so that oil vapor will not be discharged into a building from the liquid fuel supply system. Liquid-level indicating gauges shall comply with UL 180.

M2205.5 (1306.5) Gauge glass. A tank used in connection with any oil burner shall not be equipped with a glass gauge or any gauge *whichthat*, when broken, will permit the escape of oil from the tank.

CHAPTER 23

SOLAR THERMAL ENERGY SYSTEMS

User notes:

— **About this chapter:** Chapter 23 is specific to thermal solar systems and equipment. Solar voltaic systems are not addressed in this chapter. This chapter covers solar collectors, system design, safety devices, relief valves, freeze protection, expansion tanks, signage, labeling, heat transfer fluids, protection of potable water and potable water heating.

— **Code development reminder:** Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

The text of this chapter is extracted from the 2018 edition of the North Carolina Mechanical Code and has been modified where necessary to conform to the scope of application of the North Carolina Residential Code for One- and Two-Family Dwellings. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the North Carolina Mechanical Code.

SECTION M2301

SOLAR THERMAL ENERGY SYSTEMS

M2301.1 (1401.1) General. This section provides for the design, construction, installation, alteration and repair of equipment and systems using solar thermal energy to provide space heating or cooling, hot water heating and swimming pool heating.

M2301.2 Design and installation. The design and installation of solar thermal energy systems shall comply with Sections M2301.2.1 through M2301.2.13.

M2301.2.1 Access. Access shall be provided to solar energy equipment for maintenance. Solar systems and appurtenances shall not obstruct or interfere with the operation of any doors, windows or other building components requiring operation or access. Roof-mounted solar thermal equipment shall not obstruct or interfere with the operation of roof-mounted equipment, appliances, chimneys, plumbing vents, roof hatches, smoke vents, skylights and other roof penetrations and openings.

M2301.2.2.1 Roof-mounted collectors. The roof shall be constructed to support the loads imposed by roof-mounted solar collectors. Roof-mounted solar collectors that serve as a roof covering shall conform to the requirements for roof coverings in Chapter 9 of this code. Where mounted on or above the roof coverings, the collectors and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction.

M2301.2.2.2 Collector sensors. Collector sensor installation, sensor location and the protection of exposed sensor wires from degradation shall be in accordance with ICC 900/SRCC 300.

M2301.2.3 Pressure and temperature relief valves and system components. System components containing fluids shall be protected with temperature and pressure relief valves or pressure relief valves. Relief devices shall be installed in sections of the system so that a section cannot be valved off or isolated from a relief device. Direct systems and the potable water portion of indirect systems shall be equipped with a relief valve in accordance with Section P2804. For indirect systems, pressure relief valves in solar loops shall comply with ICC 900/SRCC 300. System components shall have a working pressure rating of not less than the setting of the pressure relief device.

M2301.2.4 Vacuum relief. System components that might be subjected to a vacuum during operation or shutdown shall be designed to withstand such a vacuum or shall be protected with vacuum-relief valves.

M2301.2.6 Protection from freezing. System components shall be protected from damage resulting from freezing of heat-transfer liquids at the winter design temperature provided in Table R301.2. Freeze protection shall be provided in accordance with ICC 900/SRCC 300. Drain-back systems shall be installed in compliance with Section M2301.2.6.1. Systems utilizing freeze-protection valves shall comply with Section M2301.2.6.2.

Exception: Where the 97.5-percent winter design temperature is greater than or equal to 48°F (9°C).

M2301.2.6.1 Drain-back systems. Drain-back systems shall be designed and installed to allow for manual gravity draining of fluids from areas subject to freezing to locations not subject to freezing, and air filling of the components and piping. Such piping and components shall maintain a horizontal slope in the direction of flow of not less than 1/4 unit vertical in 12 units horizontal (2-percent slope). Piping and components subject to manual gravity draining shall permit subsequent air filling upon drainage and air venting upon refilling.

M2301.2.6.2 Freeze-protection valves. Freeze-protection valves shall discharge in a manner that does not create a hazard or structural damage.

M2301.2.7 Storage tank sensors. Storage tank sensors shall comply with ICC 900/SRCC 300.

M2301.2.8 Expansion tanks. Expansion tanks in *solar energy systems* shall be installed in accordance with Section M2003 in solar collector loops that contain pressurized heat transfer fluid. Where expansion tanks are used, the system shall be designed in accordance with ICC 900/SRCC 300 to provide an expansion tank that is sized to withstand the maximum operating pressure of the system.

Exception: Expansion tanks shall not be required in *the collector loop of drain-back systems*.

M2301.2.9 Roof and wall penetrations. Roof and wall penetrations shall be flashed and sealed in accordance with Chapter 9 to prevent entry of water, rodents and insects.

M2301.2.10 Description and warning labels. Solar thermal systems shall comply with description *label* and warning *label* requirements of Section M2301.2.11.2 and ICC 900/SRCC 300.

M2301.2.11.1 Solar loop isolation. Valves shall be installed to allow the solar *loop* to be isolated from the remainder of the system.

M2301.2.11.2 Drain and fill valve labels and caps. Drain and fill valves shall be *labeled* with a description and warning that identifies the fluid in the solar loop and a warning that the fluid might be discharged at high temperature and pressure. Drain caps shall be installed at drain and fill valves.

M2301.2.12 Maximum temperature limitation. Systems shall be equipped with means to limit the maximum water temperature of the system fluid entering or exchanging heat with any pressurized vessel inside the *dwelling* to 180°F (82°C). This protection is in addition to the required temperature and pressure-relief valves required by Section M2301.2.3.

M2301.2.13 Thermal storage unit seismic bracing. In *Seismic Design Categories* D₀, D₁ and D₂ and in townhouses in Seismic Design Category C, thermal storage units shall be anchored in accordance with Section M1307.2.

M2301.3.1 Collectors and panels. Solar thermal collectors and panels shall be *listed* and *labeled* in accordance with ICC 901/SRCC 100. Factory-built collectors shall bear a *label* indicating the manufacturer's name, model number and serial number.

M2301.3.2 Thermal storage units. Pressurized *water* storage *tanks* shall bear a *label* indicating the manufacturer's name and address, model number, serial number, storage unit maximum and minimum allowable operating temperatures and *storage unit maximum and minimum allowable operating pressures*. The *label* shall clarify that these specifications apply only to the *water* storage *tanks*.

M2301.4 Heat transfer *gases* or liquids and heat exchangers. *Essentially toxic transfer fluids*, ethylene glycol, flammable gases and flammable liquids shall not be used as heat transfer fluids. Heat transfer *gases* and liquids shall be rated to withstand the system's maximum design temperature under operating conditions without degradation. Heat exchangers used in solar thermal systems shall comply with Section P2902.5.2 and ICC 900/SRCC 300.

Heat transfer fluids shall be in accordance with ICC 900/SRCC 300. The flash point of the heat transfer fluids utilized in solar thermal systems shall be not less than 50°F (28°C) above the design maximum nonoperating or no-flow temperature attained by the fluid in the collector.

M2301.5 ~~(1401.2)~~ Backflow protection. Connections from the potable water supply to solar systems shall comply with Section P2902.5.5.

The text of this chapter is extracted from the 2021 edition of the *International North Carolina Fuel Gas Code* and has been modified where necessary to conform to the scope of application of the *International North Carolina Residential Code for One- and Two-Family Dwellings*. The section numbers appearing in parentheses after each section number are the section numbers of the corresponding text in the *International North Carolina Fuel Gas Code*.

User notes:

About this chapter: Chapter 24 addresses fuel gas piping, appliances, combustion air, appliance venting and specific appliances, among other subjects. Note that Chapter 24 includes definitions that are unique to this chapter. The text of this chapter is identical to that of the *International Fuel Gas Code*[®], except that this chapter contains coverage only for that which is typically found in residential occupancies, consistent with the scope of this code.

Code development reminder: Code change proposals to this chapter will be considered by the IRC—Plumbing/Mechanical Code Development Committee during the 2021 (Group A) Code Development Cycle. See explanation on page iv.

SECTION G2401 (101) GENERAL

G2401.1 (101.2) Application. This chapter covers those fuel gas *piping systems*, fuel-gas *appliances* and related accessories, *venting systems* and *combustion air* configurations most commonly encountered in the construction of one- and two-family dwellings and structures regulated by this *code*.

Coverage of *piping systems* shall extend from the *point of delivery* to the outlet of the *appliance* shutoff valves (see definition of “*Point of delivery*”). *Piping systems* requirements shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance. Requirements for gas *appliances* and related accessories shall include installation, combustion and ventilation air and venting and connections to *piping systems*.

The omission from this chapter of any material or method of installation provided for in the *International Fuel Gas Code* shall not be construed as prohibiting the use of such material or method of installation. Fuel-gas *piping systems*, fuel-gas *appliances* and related accessories, *venting systems* and *combustion air* configurations not specifically covered in these chapters shall comply with the applicable provisions of the *International Fuel Gas Code*.

Gaseous hydrogen systems shall be regulated by Chapter 7 of the *International Fuel Gas Code*.

This chapter shall not apply to the following:

1. Liquefied natural gas (LNG) installations.
2. Temporary LP-gas *piping* for buildings under construction or renovation that is not to become part of the permanent *piping system*.
3. Except as provided in Section G2412.1.1, gas *piping*, meters, gas pressure regulators, and other appurtenances used by the serving gas supplier in the distribution of gas, other than undiluted LP-gas.
4. Portable LP-gas *appliances* and equipment of all types that is not connected to a fixed fuel *piping system*.
5. Portable fuel cell *appliances* that are neither connected to a fixed *piping system* nor interconnected to a power grid.
6. Installation of hydrogen gas, LP-gas and compressed natural gas (CNG) systems on vehicles.

G2401.2 (102.6) Historic buildings. The provisions of this code relating to the construction, *alteration*, repair, enlargement, restoration, relocation or moving of buildings or structures shall not be mandatory for existing buildings or structures identified and classified by the state or local jurisdiction as historic buildings where such buildings or structures are judged by the *code official* to be safe and in the public interest of health, safety and welfare regarding any proposed construction, *alteration*, repair, enlargement, restoration, relocation or moving of buildings.

SECTION G2402 (201) GENERAL

G2402.1 (201.1) Scope. Unless otherwise expressly stated, the following words and terms shall, for the purposes of this chapter, have the meanings indicated in this chapter.

G2402.2 (201.2) Interchangeability. Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural, the singular.

G2402.3 (201.3) Terms defined in other codes. Where terms are not defined in this code and are defined in the *International Building Code*, *International Fire Code*, *International Mechanical Code*, *International Fuel Gas Code* or *International Plumbing Code*, such terms shall have meanings ascribed to them as in those codes.

SECTION G2403 (202) GENERAL DEFINITIONS

Deleted. See Chapter 2

ACCESS (TO). That which enables a device, *appliance* or equipment to be reached by ready *access* or by a means that first requires the removal or movement of a panel, door or similar obstruction (see also “*Ready access*”).

AIR, EXHAUST. Air being removed from any space or piece of *equipment* or *appliance* and conveyed directly to the atmosphere by means of openings or ducts.

AIR, MAKEUP. Any combination of outdoor and transfer air intended to replace exhaust air and exfiltration.

AIR CONDITIONER, GAS FIRED. A gas burning, automatically operated *appliance* for supplying cooled and/or air, dehumidified air, or both, or chilled liquid.

AIR CONDITIONING. The treatment of air so as to control simultaneously the temperature, humidity, cleanness and distribution of the air to meet the requirements of a *conditioned space*.

AIR HANDLING UNIT. A blower or fan used for the purpose of distributing supply air to a room, space or area.

ALTERATION. A change in a system that involves an extension, addition or change to the arrangement, type or purpose of the original installation.

ANODELESS RISER. A transition assembly in which plastic *pipng* is installed and terminated above ground outside of a building.

APPLIANCE. Any apparatus or device that utilizes a fuel or a raw material as a fuel to produce light, heat, power, refrigeration or air conditioning. Also, an apparatus that compresses fuel gases.

APPLIANCE, AUTOMATICALLY CONTROLLED. *Appliances* equipped with an automatic *burner* ignition and safety shut off device and other automatic devices, that accomplish complete turn on and shut off of the gas to the *main burner* or *burners*, and graduate the gas supply to the *burner* or *burners*, but do not affect complete shut off of the gas.

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.

APPLIANCE, UNVENTED. An *appliance* designed or installed in such a manner that the products of combustion are not conveyed by a vent or *chimney* directly to the outside atmosphere.

APPLIANCE, VENTED. An *appliance* designed and installed in such a manner that all of the products of combustion are conveyed directly from the *appliance* to the outside atmosphere through an *approved chimney* or vent system.

APPROVED. Acceptable to the *code official*.

APPROVED AGENCY. An established and recognized agency that is regularly engaged in conducting tests or, furnishing inspection services or furnishing certification, where such agency has been approved by the *code official*.

ATMOSPHERIC PRESSURE. The pressure of the weight of air and water vapor on the surface of the earth, approximately 14.7 pounds per square inch (psia) (101 kPa absolute) at sea level.

AUTOMATIC IGNITION. Ignition of gas at the *burner(s)* when the gas controlling device is turned on, including reignition if the flames on the *burner(s)* have been extinguished by means other than by the closing of the gas controlling device.

BAROMETRIC DRAFT REGULATOR. A balanced *damper* device attached to a *chimney*, vent *connector*, breeching or flue gas manifold to protect combustion *appliances* by controlling *chimney draft*. A double acting *barometric draft regulator* is one whose balancing *damper* is free to move in either direction to protect combustion *appliances* from both excessive *draft* and backdraft.

BOILER, LOW-PRESSURE. A self-contained *appliance* for supplying steam or hot water.

Hot water heating boiler. A boiler in which no steam is generated, from which hot water is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gauge (psig) (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

Hot water supply boiler. A boiler, completely filled with water, which furnishes hot water to be used externally to itself, and that operates at water pressures not exceeding 160 psig (1100 kPa gauge) and at water temperatures not exceeding 250°F (121°C) at or near the boiler outlet.

Steam heating boiler. A boiler in which steam is generated and that operates at a steam pressure not exceeding 15 psig (100 kPa gauge).

BONDING JUMPER. A conductor installed to electrically connect metallic gas *pipng* to the grounding electrode system.

BRAZING. A metal joining process wherein coalescence is produced by the use of a nonferrous filler metal having a melting point above 1,000°F (538°C), but lower than that of the base metal being joined. The filler material is distributed between the closely fitted surfaces of the joint by capillary action.

BTU. Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound (454 g) of water 1°F (0.56°C) (1 *Btu* = 1055 J).

BURNER. A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone.

Induced draft. A *burner* that depends on *draft* induced by a fan that is an integral part of the *appliance* and is located downstream from the *burner*.

Power. A *burner* in which gas, air or both are supplied at pressures exceeding, for gas, the line pressure, and for air, atmospheric pressure, with this added pressure being applied at the *burner*.

CHIMNEY. A primarily vertical structure containing one or more flues, for the purpose of carrying gaseous products of *combustion* and air from an *appliance* to the outside atmosphere.

Factory-built chimney. A *listed* and *labeled* chimney composed of factory-made components, assembled in the field in accordance with manufacturer's instructions and the conditions of the listing.

Masonry chimney. A field-constructed chimney composed of solid masonry units, bricks, stones or concrete.

CLEARANCE. The minimum distance through air measured between the heat-producing surface of the mechanical *appliance*, device or *equipment* and the surface of the *combustible material* or *assembly*.

CLOTHES DRYER. An *appliance* used to dry wet laundry by means of heated air.

Type 1. Factory-built package, multiple production. Primarily used in the family living environment. Usually the smallest unit physically and in function output.

CODE. These regulations, subsequent amendments thereto, or any emergency rule or regulation that the administrative authority having *jurisdiction* has lawfully adopted.

CODE OFFICIAL. The officer or other designated authority charged with the administration and enforcement of this code, or a duly authorized representative.

COMBUSTIBLE ASSEMBLY. Wall, floor, ceiling or other assembly constructed of one or more component materials that are not defined as noncombustible.

COMBUSTIBLE MATERIAL. Any material not defined as noncombustible.

COMBUSTION. In the context of this code, refers to the rapid oxidation of fuel accompanied by the production of heat or heat and light.

COMBUSTION AIR. Air necessary for complete combustion of a fuel, including theoretical air and excess air.

COMBUSTION CHAMBER. The portion of an *appliance* within which combustion occurs.

COMBUSTION PRODUCTS. Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inert gases, but excluding excess air.

CONCEALED LOCATION. A location that cannot be accessed without damaging permanent parts of the building structure or finish surface. Spaces above, below or behind readily removable panels or doors shall not be considered as concealed.

CONCEALED PIPING. *Piping* that is located in a *concealed location* (see "Concealed location").

CONDENSATE. The liquid that condenses from a gas (including flue gas) caused by a reduction in temperature or increase in pressure.

CONNECTOR, APPLIANCE (Fuel). Rigid metallic *pipe* and fittings, semirigid metallic *tubing* and fittings or a listed and labeled device that connects an *appliance* to the *gas piping system*.

CONNECTOR, CHIMNEY OR VENT. The *pipe* that connects an *appliance* to a chimney or vent.

CONTROL. A manual or automatic device designed to regulate the gas, air, water or electrical supply to, or operation of, a mechanical system.

CONVERSION BURNER. A unit consisting of a *burner* and its *controls* for installation in an *appliance* originally utilizing another fuel.

COPPER ALLOY. A homogeneous mixture of not less than two metals where not less than 50 percent of the finished metal is copper.

CUBIC FOOT. The amount of gas that occupies 1 cubic foot (0.02832 m³) when at a temperature of 60°F (16°C), saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury (101 kPa).

DAMPER. A manually or automatically controlled device to regulate *draft* or the rate of flow of air or combustion gases.

DECORATIVE APPLIANCE, VENTED. A *vented appliance* wherein the primary function lies in the aesthetic effect of the flames.

DECORATIVE APPLIANCES FOR INSTALLATION IN VENTED FIREPLACES. A *vented appliance* designed for installation within the fire chamber of a *vented fireplace*, wherein the primary function lies in the aesthetic effect of the flames.

DEMAND. The maximum amount of gas input required per unit of time, usually expressed in cubic feet per hour, or Btu/h (1 Btu/h = 0.2931 W).

DESIGN FLOOD ELEVATION. The elevation of the “design flood,” including wave height, relative to the datum specified on the community’s legally designated flood hazard map. In areas designated as Zone AO, the *design flood elevation* shall be the elevation of the highest existing grade of the *building’s* perimeter plus the depth number, (in feet,) specified on the flood hazard map. In areas designated as Zone AO where a depth number is not specified on the map, the depth number shall be taken as being equal to 2 feet (610 mm).

DILUTION AIR. Air that is introduced into a *draft hood* and is mixed with the *flue gases*.

DIRECT VENT APPLIANCES. *Appliances* that are constructed and installed so that all air for combustion is derived directly from the outside atmosphere and all *flue gases* are discharged directly to the outside atmosphere.

DRAFT. The pressure difference existing between the *appliance* or any component part and the atmosphere, that causes a continuous flow of air and products of combustion through the gas passages of the *appliance* to the atmosphere.

Mechanical or induced draft. The pressure difference created by the action of a fan, blower or ejector that is located between the *appliance* and the chimney or vent termination.

Natural draft. The pressure difference created by a vent or chimney because of its height, and the temperature difference between the *flue gases* and the atmosphere.

DRAFT HOOD. A nonadjustable device built into an *appliance*, or made as part of the vent *connector* from an *appliance*, that is designed to (1) provide for 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*, and (3) neutralize the effect of stack action of the chimney or gas vent upon operation of the *appliance*.

DRAFT REGULATOR. A device that functions to maintain a desired *draft* in the *appliance* by automatically reducing the *draft* to the desired value.

DRIP. The container placed at a low point in a system of *piping* to collect *condensate* and from which the *condensate* is removable.

DUCT FURNACE. A warm air *furnace* normally installed in an air distribution duct to supply warm air for heating. This definition shall apply only to a warm air heating *appliance* that depends for air circulation on a blower not furnished as part of the *furnace*.

DWELLING UNIT. A single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking and sanitation.

EQUIPMENT. Apparatus and devices other than *appliances*.

EXCESS FLOW VALVE (EFV). A valve designed to activate when the fuel gas passing through it exceeds a prescribed flow rate.

EXTERIOR MASONRY CHIMNEYS. Masonry chimneys exposed to the outdoors on one or more sides below the roof line.

FIREPLACE. A fire chamber and hearth constructed of *non-combustible material* for use with solid fuels and provided with a chimney.

Factory-built fireplace. A *fireplace* composed of *listed* factory built components assembled in accordance with the terms of listing to form the completed *fireplace*.

Masonry fireplace. A hearth and fire chamber of solid masonry units such as bricks, stones, *listed* masonry units or reinforced concrete, provided with a suitable chimney.

FLAME SAFEGUARD. A device that will automatically shut off the fuel supply to a *main burner* or group of *burners* when the means of ignition of such *burners* becomes inoperative, and when flame failure occurs on the *burner* or group of *burners*.

FLASHBACK ARRESTOR CHECK VALVE. A device that will prevent the backflow of one gas into the supply system of another gas and prevent the passage of flame into the gas supply system.

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. This area designated as a *flood hazard area* on a community's flood hazard map, or otherwise legally designated.

FLOOR FURNACE. A completely self-contained *furnace* suspended from the floor of the space being heated, taking air for combustion from outside such space and with means for observing flames and lighting the *appliance* from such space.

FLUE, APPLIANCE. The passage(s) within an *appliance* through which *combustion products* pass from the *combustion chamber* of the *appliance* to the *draft hood* inlet opening on an *appliance* equipped with a *draft hood* or to the outlet of the *appliance* on an *appliance* not equipped with a *draft hood*.

FLUE COLLAR. That portion of an *appliance* designed for the attachment of a *draft hood*, *vent connector* or venting system.

FLUE GASES. Products of combustion plus excess air in *appliance flues* or heat exchangers.

FLUE LINER (LINING). A system or material used to form the inside surface of a flue in a *chimney* or vent, for the purpose of protecting the surrounding structure from the effects of *combustion products* and for conveying *combustion products* without leakage to the atmosphere.

FUEL GAS. A natural gas, manufactured gas, *liquefied petroleum gas* or mixtures of these gases.

FURNACE. A completely self-contained heating unit that is designed to supply heated air to spaces remote from or adjacent to the *appliance* location.

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.

FURNACE PLENUM. An air compartment or chamber to which one or more ducts are connected and that forms part of an air distribution system.

GAS CONVENIENCE OUTLET. A permanently mounted, manually operated device that provides the means for connecting an *appliance* to, and disconnecting an *appliance* from, the supply *pipng*. The device includes an integral, manually operated valve with a nondisplaceable valve member and is designed so that disconnection of an *appliance* only occurs when the manually operated valve is in the closed position.

GAS PIPING. An installation of pipe, valves or fittings installed on a premises or in a building and utilized to convey fuel gas.

HAZARDOUS LOCATION. Any location considered to be a fire hazard for flammable vapors, dust, combustible fibers or other highly combustible substances. The location is not necessarily categorized in the *International Building Code* as a high-hazard use group classification.

HOUSE PIPING. See “*Piping system.*”

IGNITION PILOT. A *pilot* that operates during the lighting cycle and discontinues during *main burner* operation.

IGNITION SOURCE. A flame spark or hot surface capable of igniting flammable vapors or fumes. Such sources include *appliance burners*, *burner ignitors* and electrical switching devices.

INFRARED RADIANT HEATER. A heater that directs a substantial amount of its energy output in the form of infrared radiant energy into the area to be heated. Such heaters are of either the vented or unvented type.

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. A general form of gastight joints obtained by the joining of metal parts through a positive-holding mechanical construction, such as a press connect joint, flanged joint, threaded joint, flared joint or compression joint.

JOINT, PLASTIC ADHESIVE. A joint made in thermoset plastic *piping* by the use of an adhesive substance that forms a continuous bond between the mating surfaces without dissolving either one of them.

LABELED. Equipment, materials or products to which have been affixed a *label*, seal, symbol or other identifying *mark* of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above *labeled* items and whose labeling indicates either that the *equipment*, material or product meets identified standards or has been tested and found suitable for a specified purpose.

LEAK CHECK. An operation performed on a gas *piping system* to verify that the system does not leak.

LIQUEFIED PETROLEUM GAS or LPG (LP-GAS). *Liquefied petroleum gas* composed predominately of propane, propylene, butanes or butylenes, or mixtures thereof that is gaseous under normal atmospheric conditions, but is capable of being liquefied under moderate pressure at normal temperatures.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of *listed equipment* or materials or periodic evaluation of services and whose listing states either that the *equipment*, material, product or service meets identified standards or has been tested and found suitable for a specified purpose.

LIVING SPACE. Space within a *dwelling unit* utilized for living, sleeping, eating, cooking, bathing, washing and sanitation purposes.

LOG LIGHTER. A manually operated solid fuel ignition *appliance* for installation in a vented solid fuel burning *fireplace*.

MAIN BURNER. A device or group of devices essentially forming an integral unit for the final conveyance of gas or a mixture of gas and air to the combustion zone, and on which combustion takes place to accomplish the function for which the *appliance* is designed.

METER. The instrument installed to measure the volume of gas delivered through it.

MODULATING. Modulating or throttling is the action of a *control* from its maximum to minimum position in either predetermined steps or increments of movement as caused by its actuating medium.

NONCOMBUSTIBLE MATERIALS. Materials that, where tested in accordance with ASTM E136, have not fewer than three of four specimens tested meeting all of the following criteria:

- 1.—The recorded temperature of the surface and interior thermocouples shall not at any time during the test rise more than 54°F (30°C) above the furnace temperature at the beginning of the test.
- 2.—There shall not be flaming from the specimen after the first 30 seconds.
- 3.—If the weight loss of the specimen during testing exceeds 50 percent, the recorded temperature of the surface and interior thermocouples shall not at any time during the test rise above the furnace air temperature at the beginning of the test, and there shall not be flaming of the specimen.

OFFSET (VENT). A combination of *approved* bends that make two changes in direction bringing one section of the vent out of line, but into a line parallel with the other section.

OUTLET. The point at which a gas-fired *appliance* connects to the *gas piping system*.

OXYGEN DEPLETION SAFETY SHUTOFF SYSTEM (ODS). A system designed to act to shut off the gas supply to the main and *pilot burners* if the oxygen in the surrounding atmosphere is reduced below a predetermined level.

PILOT. A small flame that is utilized to ignite the gas at the *main burner* or *burners*.

PIPING. Where used in this code, "*piping*" refers to either *pipe* or *tubing*, or both.

Pipe. A rigid conduit of iron, steel, copper, **copper alloy** or plastic.

Tubing. Semirigid conduit of copper, **copper alloy**, aluminum, plastic or steel.

PIPING SYSTEM. The fuel *piping*, valves and fittings from the outlet of the *point of delivery* to the outlets of the *appliance* shutoff valves.

PLASTIC, THERMOPLASTIC. A plastic that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

POINT OF DELIVERY. For natural gas systems, the *point of delivery* is the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where a meter is not provided. Where a **system shutoff** valve is provided **after** the outlet of the service meter assembly, such valve shall be considered to be downstream of the *point of delivery*. For undiluted liquefied petroleum gas systems, the **point of delivery** shall be considered to be the outlet of the service pressure regulator, exclusive of line gas regulators, in the system.

PRESS CONNECT JOINT. A permanent mechanical joint incorporating an elastomeric seal or an elastomeric seal and corrosion resistant grip or bite ring. The joint is made with a pressing tool and jaw or ring approved by the fitting manufacturer.

PRESSURE DROP. The loss in pressure due to friction or obstruction in pipes, valves, fittings, *regulators* and *burners*.

PRESSURE TEST. An operation performed to verify the gastight integrity of *gas piping* following its installation or modification.

PURGE. To free a gas conduit of air or gas, or a mixture of gas and air.

READY ACCESS (TO). That which enables a device, *appliance* or *equipment* to be directly reached, without requiring the removal or movement of any panel, door or similar obstruction. (See "**Access.**")

REGULATOR. A device for controlling and maintaining a uniform gas supply pressure, either pounds to inches water column (MP regulator) or inches to inches water column (*appliance regulator*).

REGULATOR, GAS APPLIANCE. A *pressure regulator* for controlling pressure to the manifold of the *gas appliance*.

REGULATOR, LINE GAS PRESSURE. A device placed in a gas line between the *service pressure regulator* and the *appliance* for controlling, maintaining or reducing the pressure in that portion of the *piping system* downstream of the device.

REGULATOR, MEDIUM PRESSURE (MP Regulator). A *line pressure regulator* that reduces gas pressure from the range of greater than 0.5 psig (3.4 kPa) and less than or equal to 5 psig (34.5 kPa) to a lower pressure.

REGULATOR, MONITORING. A pressure regulator set in series with another pressure regulator for the purpose of preventing an overpressure in the downstream piping system.

REGULATOR, PRESSURE. A device placed in a gas line for reducing, controlling and maintaining the pressure in that portion of the *piping system* downstream of the device.

REGULATOR, SERVICE PRESSURE. For natural gas systems, a device installed by the serving gas supplier to reduce and limit the service line pressure to delivery pressure. For undiluted liquefied petroleum gas systems, the regulator located upstream from all line gas pressure regulators, where installed, and downstream from any first stage or a high pressure regulator in the system.

RELIEF OPENING. The opening provided in a *draft hood* to permit the ready escape to the atmosphere of the flue products from the *draft hood* in the event of no *draft*, backdraft or stoppage beyond the *draft hood*, and to permit air into the *draft hood* in the event of a strong chimney updraft.

RELIEF VALVE (DEVICE). A safety valve designed to forestall the development of a dangerous condition by relieving either pressure, temperature or vacuum in the hot water supply system.

RELIEF VALVE, PRESSURE. An *automatic valve* that opens and closes a relief vent, depending on whether the pressure is above or below a predetermined value.

RELIEF VALVE, TEMPERATURE.

Manual reset type. A valve that automatically opens a *relief vent* at a predetermined temperature and that must be manually returned to the closed position.

Reseating or self-closing type. An *automatic valve* that opens and closes a relief vent, depending on whether the temperature is above or below a predetermined value.

RELIEF VALVE, VACUUM. A valve that automatically opens and closes a vent for relieving a vacuum within the hot water supply system, depending on whether the vacuum is above or below a predetermined value.

RISER, GAS. A vertical *pipe* supplying fuel gas.

ROOM HEATER, UNVENTED. See "*Unvented room heater.*"

ROOM HEATER, VENTED. A free-standing heating unit used for direct heating of the space in and adjacent to that in which the unit is located. (See also "*Vented room heater.*")

SAFETY SHUTOFF DEVICE. See "*Flame safeguard.*"

SERVICE METER ASSEMBLY. The meter, valve, regulator, piping, fittings and equipment installed by the service gas supplier before the *point of delivery*.

SHAFT. An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors, or floors and the roof.

SPECIFIC GRAVITY. As applied to gas, *specific gravity* is the ratio of the weight of a given volume to that of the same volume of air, both measured under the same condition.

SYSTEM SHUTOFF. A valve installed after the *point of delivery* to shut off the entire piping system.

THERMOSTAT. (See types that follow.)

Electric switch type. A device that senses changes in temperature and controls electrically, by means of separate components, the flow of gas to the *burner(s)* to maintain selected temperatures.

Integral gas valve type. An automatic device, actuated by temperature changes, designed to control the gas supply to the burner(s) in order to maintain temperatures between predetermined limits, and in which the thermal actuating element is an integral part of the device.

- 1.—Graduating thermostat. A thermostat in which the motion of the valve is approximately in direct proportion to the effective motion of the thermal element induced by temperature change.
- 2.—Snap acting thermostat. A thermostat in which the thermostatic valve travels instantly from the closed to the open position, and vice versa.

THIRD PARTY CERTIFICATION AGENCY. An *approved* agency operating a product or material certification system that incorporates initial product testing, assessment and surveillance of a manufacturer's quality control system.

THIRD PARTY CERTIFIED. Certification obtained by the manufacturer indicating that the function and performance characteristics of a product or material have been determined by testing and ongoing surveillance by an *approved* third party certification agency. Assertion of certification is in the form of identification in accordance with the requirements of the third party certification agency.

THIRD PARTY TESTED. Procedure by which an *approved* testing laboratory provides documentation that a product, material or system conforms to specified requirements.

TOILET, GAS FIRED. A packaged and completely assembled *appliance* containing a toilet that incinerates refuse instead of flushing it away with water.

TRANSITION FITTINGS, PLASTIC TO STEEL. An adapter for joining plastic *pipe* to steel *pipe*. The purpose of this fitting is to provide a permanent, pressure-tight connection between two materials that cannot be joined directly one to another.

UNIT HEATER. A self contained, automatically controlled, vented, fuel gas burning, space heating *appliance*, intended for installation in the space to be heated without the use of ducts, and having integral means for circulation of air.

UNVENTED ROOM HEATER. An unvented heating *appliance* designed for stationary installation and utilized to provide comfort heating. Such *appliances* provide radiant heat or convection heat by gravity or fan circulation directly from the heater and do not utilize ducts.

VALVE. A device used in *pipng* to control the gas supply to any section of a system of *pipng* or to an *appliance*.

Appliance shutoff. A *valve* located in the *pipng system*, used to isolate individual *appliances* for purposes such as service or replacement.

Automatic. An automatic or semiautomatic device consisting essentially of a *valve* and an operator that control the gas supply to the *burner(s)* during operation of an *appliance*. The operator shall be actuated by application of gas pressure on a flexible diaphragm, by electrical means, by mechanical means or by other *approved* means.

Automatic gas shutoff. A *valve* used in conjunction with an automatic gas shutoff device to shut off the gas supply to a water heating system. It shall be constructed integrally with the gas shutoff device or shall be a separate assembly.

Individual main burner. A *valve* that controls the gas supply to an individual *main burner*.

Main burner control. A *valve* that controls the gas supply to the *main burner* manifold.

Manual main gas control. A manually operated *valve* in the gas line for the purpose of completely turning on or shutting off the gas supply to the *appliance*, except to *pilot* or *pilots* that are provided with independent shutoff.

Manual reset. An automatic shutoff *valve* installed in the gas supply *pipng* and set to shut off when unsafe conditions occur. The device remains closed until manually reopened.

Service shutoff. A *valve*, installed by the serving gas supplier between the *service meter* or source of supply and the *customer pipng system point of delivery*, to shut off the entire *pipng system*.

VENT. A *pipe* or other conduit composed of factory made components, containing a passageway for conveying *combustion products* and air to the atmosphere, *listed* and *labeled* for use with a specific type or class of *appliance*.

Special gas vent. A *vent listed* and *labeled* for use with *listed* Category II, III and IV gas *appliances*.

Type B vent. A *vent listed* and *labeled* for use with *appliances* with *draft hoods* and other Category I *appliances* that are *listed* for use with Type B vents.

Type BW vent. A *vent listed* and *labeled* for use with wall *furnaces*.

Type L vent. A *vent listed* and *labeled* for use with *appliances* that are *listed* for use with Type L or Type B vents.

VENT CONNECTOR. See "*Connector, Chimney or Vent.*"

VENT PIPING.

Breather. *Pipng* run from a pressure regulating device to the outdoors, designed to provide a reference to *atmospheric pressure*. If the device incorporates an integral pressure *relief* mechanism, a breather vent can also serve as a *relief vent*.

Relief. *Pipng* run from a pressure regulating or pressure limiting device to the outdoors, designed to provide for the safe venting of gas in the event of excessive pressure in the *gas pipng system*.

VENTED APPLIANCE CATEGORIES. *Appliances* that are categorized for the purpose of vent selection are classified into the following four 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.

Category II. An *appliance* that operates with a nonpositive *vent* static pressure and with a vent gas temperature that is capable of causing excessive *condensate* production in the vent.

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.

Category IV. An *appliance* that operates with a positive vent static pressure and with a vent gas temperature that is capable of causing excessive *condensate* production in the vent.

VENTED ROOM HEATER. A vented self-contained, free-standing, nonrecessed *appliance* for furnishing warm air to the space in which it is installed, directly from the heater without duct connections.

VENTED WALL FURNACE. A self-contained vented *appliance* complete with grilles or equivalent, designed for incorporation in or permanent attachment to the structure of a building, mobile home or travel trailer, and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing. This definition shall exclude *floor furnaces, unit heaters and central furnaces* as herein defined.

VENTING SYSTEM. A continuous open passageway from the *flue collar* or *draft hood* of an *appliance* to the outdoor atmosphere for the purpose of removing flue or vent gases. A venting system is usually composed of a vent or a chimney and *vent connector*, if used, assembled to form the open passageway.

WALL HEATER, UNVENTED TYPE. A room heater of the type designed for insertion in or attachment to a wall or partition. Such heater does not incorporate concealed venting arrangements in its construction and discharges all products of *combustion* through the front into the room being heated.

WATER HEATER. Any heating *appliance* or *equipment* that heats potable water and supplies such water to the potable hot water distribution system.

SECTION G2404 (301) GENERAL

G2404.1 (301.1) Scope. This section shall govern the approval and installation of all *equipment* and *appliances* that comprise parts of the installations regulated by this *code* in accordance with Section G2401.

G2404.2 (301.1.1) Other fuels. The requirements for *combustion* and *dilution air* for gas-fired *appliances* shall be governed by Section G2407. The requirements for *combustion* and *dilution air* for *appliances* operating with fuels other than fuel gas shall be regulated by Chapter 17.

G2404.3 (301.3) Listed and labeled. *Appliances* regulated by this *code* shall be *listed* and *labeled* for the application in which they are used unless otherwise *approved* in accordance with Section R104.11105 of the North Carolina Administrative Code and Policies. The approval of unlisted *appliances* in accordance with Section R104.11105 of the North Carolina Administrative Code and Policies shall be based **on** *approved* engineering evaluation.

G2404.4 (301.8) Vibration isolation. Where means for isolation of vibration of an *appliance* is installed, an *approved* means for support and restraint of that *appliance* shall be provided.

G2404.5 (301.9) Repair. Defective material or parts shall be replaced or repaired in such a manner so as to preserve the original approval or listing.

G2404.6 (301.10) Wind resistance. *Appliances* and supports that are exposed to wind shall be designed and installed to resist the wind pressures determined in accordance with this *code*.

G2404.7 (301.11) Flood hazard. For structures located in flood hazard areas, the **appliance**, *equipment* and system installations regulated by this *code* shall be located at or above the elevation required by Section R322 for utilities and attendant equipment.

Exception: The **appliance**, *equipment* and system installations regulated by this *code* are permitted to be located below the elevation required by Section R322 for utilities and attendant equipment provided that they are designed and installed to prevent water from entering or accumulating within the components and to resist hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to such elevation.

G2404.8 (301.12) Seismic resistance. **Where** earthquake loads are applicable in accordance with this *code*, the supports shall be designed and installed for the seismic forces in accordance with this *code*.

G2404.9 (301.14) Rodentproofing. Buildings or structures and the walls enclosing habitable or occupiable rooms and spaces in which persons live, sleep or work, or in which feed, food or foodstuffs are stored, prepared, processed, served or sold, shall be constructed to protect against the entry of rodents.

G2404.9.1 (301.14.1) Foundation and exterior wall sealing. Annular spaces around pipes, electric cables, conduits or other openings in the walls shall be protected against the passage of rodents by closing such opening with cement mortar, concrete masonry, silicone caulking or noncorrosive metal.

G2404.10 (307.1) Evaporators and cooling coils. *Condensate* drainage systems shall be provided for *equipment and appliances* containing evaporators and cooling coils in accordance with the *International Mechanical Code* Section M1411.

G2404.11 (307.2) Fuel-burning appliances. Liquid *combustion* byproducts of *condensing appliances* shall be collected and discharged to an *approved* plumbing fixture or disposal area in accordance with the manufacturer's instructions. *Condensate piping* shall be of *approved* corrosion-resistant material and shall be not smaller than the drain connection on the *appliance*. Such *piping* shall maintain a minimum slope in the direction of discharge of not less than $\frac{1}{8}$ unit vertical in 12 units horizontal (1-percent slope).

G2404.12 Drain pipe materials and sizes. Components of the *condensate* disposal system shall be ABS, cast iron, copper and copper alloy, cross-linked polyethylene, galvanized steel, PE-RT, polyethylene, polypropylene or PVC of PVDF pipe or tubing. Components shall be selected for the pressure and temperature rating of the installation. Joints and connections shall be made in accordance with the applicable provisions of Chapter 30. *Condensate* waste and drain line size shall be not less than $\frac{3}{4}$ -inch (19 mm) pipe size from the drain pan connection to the place of *condensate* disposal. Where the drain pipes from more than one unit are manifolded together for *condensate* drainage, the pipe or tubing shall be sized in accordance with an *approved* method. *Condensate piping for condensing appliances* shall be insulated to an R-value of not less than R-3.

G2404.13 Traps. *Condensate* drains shall be trapped as required by the *equipment or appliance* manufacturer.

G2404.101214 (307.5) Auxiliary drain pan. Category IV *condensing appliances* shall be provided with an auxiliary drain pan where damage to any building component will occur as a result of stoppage in the *condensate* drainage system. Such pan shall be installed in accordance with the applicable provisions of Section M1411.

Exception: An auxiliary drain pan shall not be required for *appliances* that automatically shut down operation in the event of a stoppage in the *condensate* drainage system.

G2404.111315 (307.6) Condensate pumps. *Condensate* pumps located in uninhabitable spaces, such as attics and crawl spaces, shall be connected to the *appliance or equipment* served such that when the pump fails, the *appliance or equipment* will be prevented from operating. Pumps shall be installed in accordance with the manufacturer's instructions.

SECTION G2405 (302) STRUCTURAL SAFETY

G2405.1 (302.1) Structural safety. The building shall not be weakened by the installation of any *gas piping*. In the process of installing or repairing any *gas piping*, the finished floors, walls, ceilings, tile work or any other part of the building or premises **that** is required to be changed or replaced shall be left in a safe structural condition in accordance with the requirements of this code.

G2405.1.1 (302.3) Cutting, notching and boring in wood members. The cutting, notching and boring of wood members shall comply with Sections G2405.1.1.1 through G2405.1.1.3.

G2405.1.1.1 (302.3.2) Joist notching and boring. Notching at the ends of joists shall not exceed one-fourth the joist depth. Holes bored in joists shall not be within 2 inches (51 mm) of the top and bottom of the joist and their diameters shall not exceed one-third the depth of the member. Notches in the top or bottom of the joist shall not exceed one-sixth the depth and shall not be located in the middle one-third of the span.

G2405.1.1.2 (302.3.3) Stud cutting and notching. In exterior walls and bearing partitions, any wood stud is permitted to be cut or notched to a depth not exceeding 25 percent of its width. Cutting or notching of studs to a depth not greater than 40 percent of the width of the stud is permitted in nonload-bearing partitions supporting no loads other than the weight of the partition.

G2405.1.1.3 (302.3.4) Bored holes. The diameter of bored holes in wood studs shall not exceed 40 percent of the stud depth. The diameter of bored holes in wood studs shall not exceed 60 percent of the stud depth in nonbearing partitions. The diameter of bored holes in wood studs shall not exceed 60 percent of the stud depth in any wall where each stud is doubled, provided that not more than two such successive doubled studs are so bored. The edge of the bored hole shall be not closer than $\frac{5}{8}$ inch (15.9 mm) to the edge of the stud. Bored holes shall not be located at the same section of stud as a cut or notch.

G2405.2 (302.4) Alterations to trusses. Truss members and components shall not be cut, drilled, notched, spliced or otherwise altered in any way without the written concurrence and approval of a *registered design professional*.

Alterations resulting in the addition of loads to any member, such as HVAC equipment and water heaters, shall not be permitted without verification that the truss is capable of supporting such additional loading.

G2405.3 (302.3.1) Engineered wood products. Cuts, notches and holes bored in trusses, *structural composite lumber*, structural glued-laminated members and I-joists are prohibited except where permitted by the manufacturer's recommendations or where the effects of such *alterations* are specifically considered in the design of the member by a *registered design professional*.

G2405.4 (302.5) Cutting, notching and boring holes in structural steel framing. The cutting, notching and boring of holes in structural steel framing members shall be as prescribed by the *registered design professional*.

G2405.5 (302.6) Cutting, notching and boring holes in cold-formed steel framing. Flanges and lips of load-bearing, cold-formed steel framing members shall not be cut or notched. Holes in webs of load-bearing, cold-formed steel framing members shall be permitted along the centerline of the web of the framing member and shall not exceed the dimensional limitations, penetration spacing or minimum hole edge distance as prescribed by the *registered design professional*. Cutting, notching and boring holes of steel floor/roof decking shall be as prescribed by the *registered design professional*.

G2405.6 (302.7) Cutting, notching and boring holes in non-structural cold-formed steel wall framing. Flanges and lips of nonstructural cold-formed steel wall studs shall be permitted along the centerline of the web of the framing member, shall not exceed 1½ inches (38 mm) in width or 4 inches (102 mm) in length, and the holes shall not be spaced less than 24 inches (610 mm) center to center from another hole or less than 10 inches (254 mm) from the bearing end.

SECTION G2406 (303) APPLIANCE LOCATION

G2406.1 (303.1) General. *Appliances* shall be located as required by this section, specific requirements elsewhere in this code and the conditions of the *equipment* and *appliance* listing. See Section M1305 for *appliance* access requirements.

G2406.2 (303.3) Prohibited locations. *Appliances* shall not be located in sleeping rooms, bathrooms, toilet rooms, ~~storage closets~~ closets used for storage or surgical rooms, or in a space that opens only into such rooms or spaces, except where the installation complies with one of the following:

1. The *appliance* is a direct-vent *appliance* installed in accordance with the conditions of the listing and the manufacturer's instructions.
2. *Vented room heaters*, wall *furnaces*, vented decorative *appliances*, vented gas *fireplaces*, vented gas *fireplace heaters* and decorative *appliances* for installation in vented solid fuel-burning *fireplaces* are installed in rooms that meet the required volume criteria of Section G2407.5.
3. A single wall-mounted *unvented room heater* is installed in a bathroom and such *unvented room heater* is equipped as specified in Section G2445.6 and has an input rating not greater than 6,000 *Btu/h* (1.76 kW). The bathroom shall meet the required volume criteria of Section G2407.5.
4. A single wall-mounted *unvented room heater* is installed in a bedroom and such *unvented room heater* is equipped as specified in Section G2445.6 and has an input rating not greater than 10,000 *Btu/h* (2.93 kW). The bedroom shall meet the required volume criteria of Section G2407.5.
5. The *appliance* is installed in a room or space that opens only into a bedroom or bathroom, and such room or space is used for no other purpose and is provided with a solid weather-stripped door equipped with an *approved* self-closing device. *Combustion air* shall be taken directly from the outdoors in accordance with Section G2407.6.
6. A clothes dryer is installed in a residential bathroom or toilet room having a permanent opening with an area of not less than 100 square inches (0.06 m²) that communicates with a space outside of a sleeping room, bathroom, toilet room or storage closet.

G2406.3 (303.6) Outdoor locations. *Appliances* installed in outdoor locations shall be either *listed* for outdoor installation or provided with protection from outdoor environmental factors that influence the operability, durability and safety of the *appliance*.

G2406.4 (303.7) Pit locations. Appliances installed in pits or excavations shall not come in direct contact with the surrounding soil and shall be installed not less than 2 inches (51 mm) above the pit floor. The sides of the pit or excavation shall be held back a minimum of not less than 12 inches (305 mm) from the appliance. Where the depth exceeds 12 inches (305 mm) below adjoining grade, the walls of the pit or excavation shall be lined with concrete or masonry, such concrete or masonry shall extend a minimum of not less than 4 inches (102 mm) above adjoining grade and shall have sufficient lateral load-bearing capacity to resist collapse. Excavation on the control side of the appliance shall extend not less than 30 inches (762 mm) horizontally. The appliance shall be protected from flooding in an approved manner.

G2406.5 (303.8) Drainage. Below grade installations shall be provided with a natural drain or an automatic lift or sump pump.

G2406.65 (303.4) Protection from vehicle impact damage. Appliances shall not be installed in a location subject to vehicle impact damage except where protected by an approved means. Protection is not required for appliances located out of the vehicle's normal travel path.

G2406.76 (303.5) Indoor locations. Furnaces and boilers installed in closets and alcoves shall be listed for such installation.

SECTION G2407 (304) COMBUSTION, VENTILATION AND DILUTION AIR

G2407.1 (304.1) General. Air for combustion, ventilation and dilution of flue gases for appliances installed in buildings shall be provided by application of one of the methods prescribed in Sections G2407.5 through G2407.9. Where the requirements of Section G2407.5 are not met, outdoor air shall be introduced in accordance with one of the methods prescribed in Sections G2407.6 through G2407.9. Direct-vent appliances, gas appliances of other than natural draft design, vented gas appliances not designated as Category I and appliances equipped with power burners, shall be provided with combustion, ventilation and dilution air in accordance with the appliance manufacturer's instructions.

Exception: Type 1 clothes dryers that are provided with makeup air in accordance with Section G2439.5.

G2407.2 (304.2) Appliance location. Appliances shall be located so as not to interfere with proper circulation of combustion, ventilation and dilution air.

G2407.3 (304.3) Draft hood/regulator location. Where used, a draft hood or a barometric draft regulator shall be installed in the same room or enclosure as the appliance served to prevent any difference in pressure between the hood or regulator and the combustion air supply.

G2407.4 (304.4) Makeup air provisions. Where exhaust fans, clothes dryers and kitchen ventilation systems interfere with the operation of appliances, makeup air shall be provided.

G2407.5 (304.5) Indoor combustion air. The required volume of indoor air shall be determined in accordance with Section G2407.5.1 or G2407.5.2, except that where the air infiltration rate is known to be less than 0.40 air changes per hour (ACH), Section G2407.5.2 shall be used. The total required volume shall be the sum of the required volume calculated for all 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 G2407.5.3, are considered to be part of the required volume.

G2407.5.1 (304.5.1) Standard method. The minimum required volume shall be 50 cubic feet per 1,000 Btu/h (4.8 m³/kW) of the appliance input rating.

G2407.5.2 (304.5.2) Known air-infiltration-rate method. Where the air infiltration rate of a structure is known, the minimum required volume shall be determined as follows:

For appliances other than fan-assisted, calculate volume using Equation 24-1.

$$\text{Required Volume}_{\text{other}} \geq \frac{21 \text{ ft}^3}{\text{ACH}} \left(\frac{I_{\text{other}}}{1,000 \text{ Btu/h}} \right)$$

(Equation 24-1)

For fan-assisted appliances, calculate volume using Equation 24-2.

$$\text{Required Volume}_{fan} \geq \frac{15 \text{ ft}^3}{ACH} \left(\frac{I_{fan}}{1,000 \text{ Btu/h}} \right)$$

(Equation 24-2)

where:

I_{other} = All appliances other than fan assisted (input in *Btu/h*).

I_{fan} = Fan-assisted appliance (input in *Btu/h*).

ACH = Air change per hour (percent of volume of space exchanged per hour, expressed as a decimal).

For purposes of this calculation, an infiltration rate greater than 0.60 *ACH* shall not be used in Equations 24-1 and 24-2.

G2407.5.3 (304.5.3) Indoor opening size and location. Openings used to connect indoor spaces shall be sized and located in accordance with Sections G2407.5.3.1 and G2407.5.3.2 (see Figure G2407.5.3).

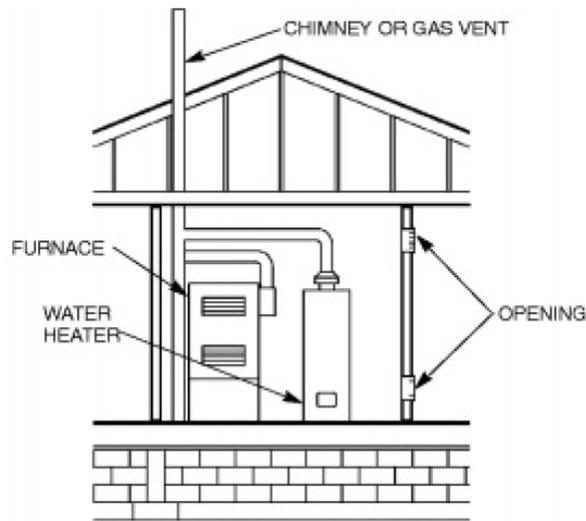


FIGURE G2407.5.3 (304.5.3)

ALL AIR FROM INSIDE THE BUILDING (see Section G2407.5.3)

G2407.5.3.1 (304.5.3.1) Combining spaces on the same story. Where combining spaces on the same story, each opening shall have a minimum free area of 1 square inch per 1,000 *Btu/h* (2,200 mm²/kW) of the total input rating of all appliances in the space, but not less than 100 square inches (0.06 m²). One permanent opening shall commence within 12 inches (305 mm) of the top and one permanent opening shall commence within 12 inches (305 mm) of the bottom of the enclosure. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

G2407.5.3.2 (304.5.3.2) Combining spaces in different stories. The volumes of spaces in different stories shall be considered to be communicating spaces where such spaces are connected by one or more permanent openings in doors or floors having a total minimum free area of 2 square inches per 1,000 *Btu/h* (4402 mm²/kW) of total input rating of all appliances.

G2407.6 (304.6) Outdoor combustion air. Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with Section G2407.6.1 or G2407.6.2. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

G2407.6.1 (304.6.1) Two-permanent-openings method. Two permanent openings, one commencing within 12 inches (305 mm) of the top 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.

Where directly communicating with the outdoors, or where communicating with the outdoors through vertical ducts, each opening shall have a minimum free area of 1 square inch per 4,000 *Btu/h* (550 mm²/kW) of total input rating of all *appliances* in the enclosure [see Figures G2407.6.1(1) and G2407.6.1(2)].

Where communicating with the outdoors through horizontal ducts, each opening shall have a minimum free area of not less than 1 square inch per 2,000 *Btu/h* (1100 mm²/kW) of total input rating of all *appliances* in the enclosure [see Figure G2407.6.1(3)].

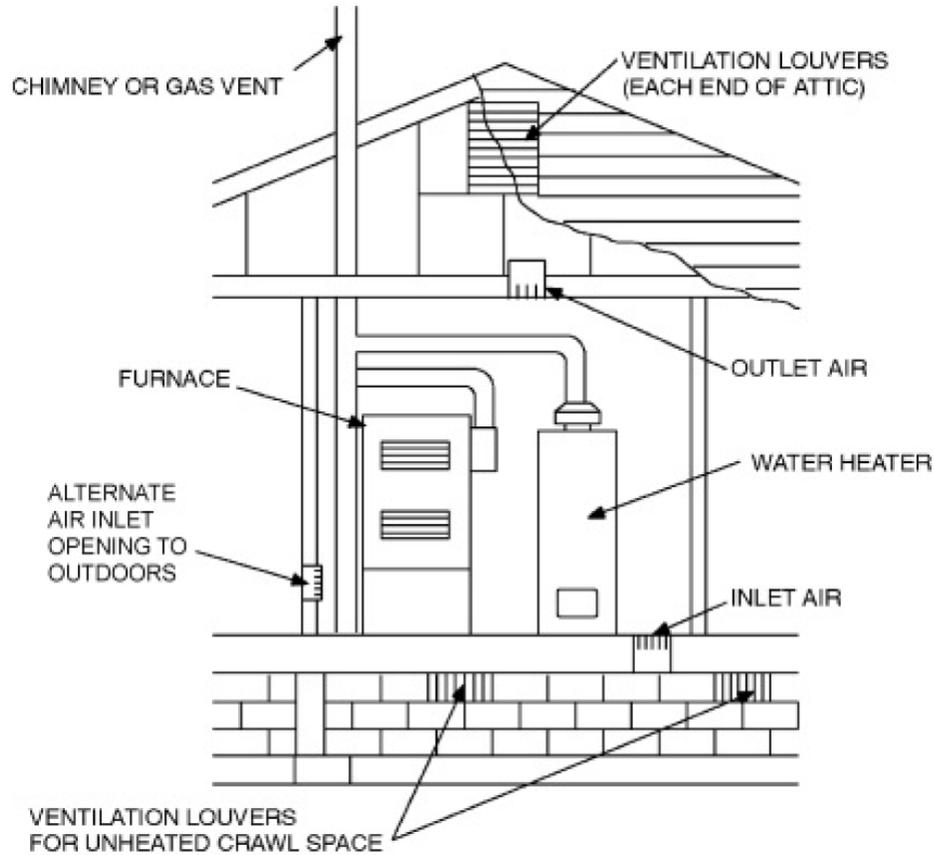
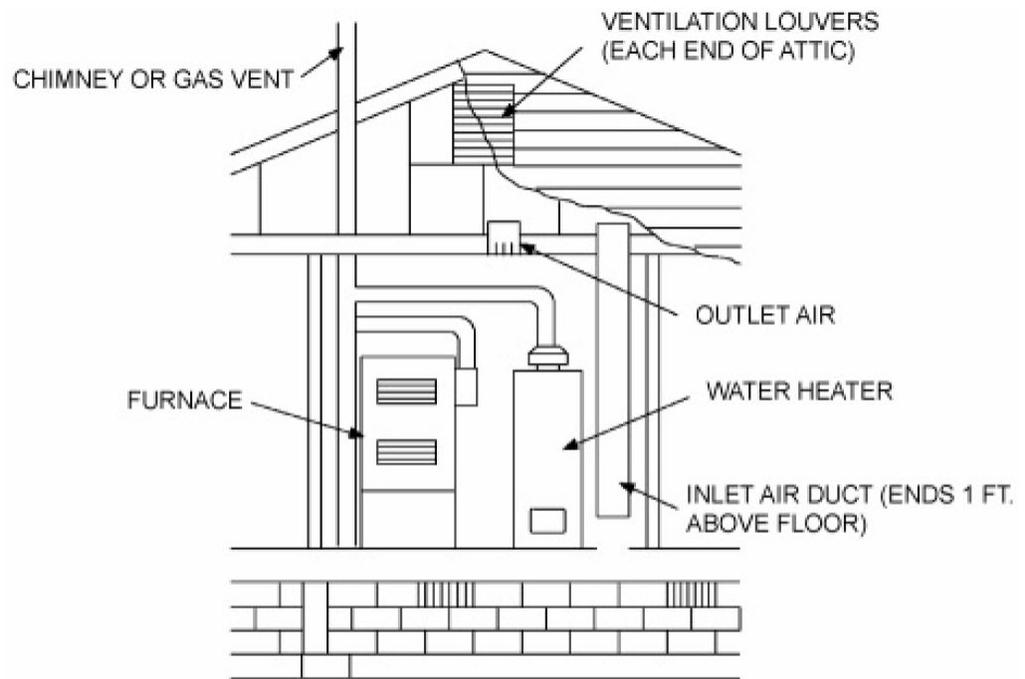


FIGURE G2407.6.1(1) [304.6.1(1)]
ALL AIR FROM OUTDOORS—INLET AIR FROM VENTILATED CRAWL SPACE
AND OUTLET AIR TO VENTILATED ATTIC (see Section G2407.6.1)



For SI: 1 foot = 304.8 mm.

FIGURE G2407.6.1(2) [304.6.1(2)]
ALL AIR FROM OUTDOORS THROUGH VENTILATED ATTIC (see Section G2407.6.1)

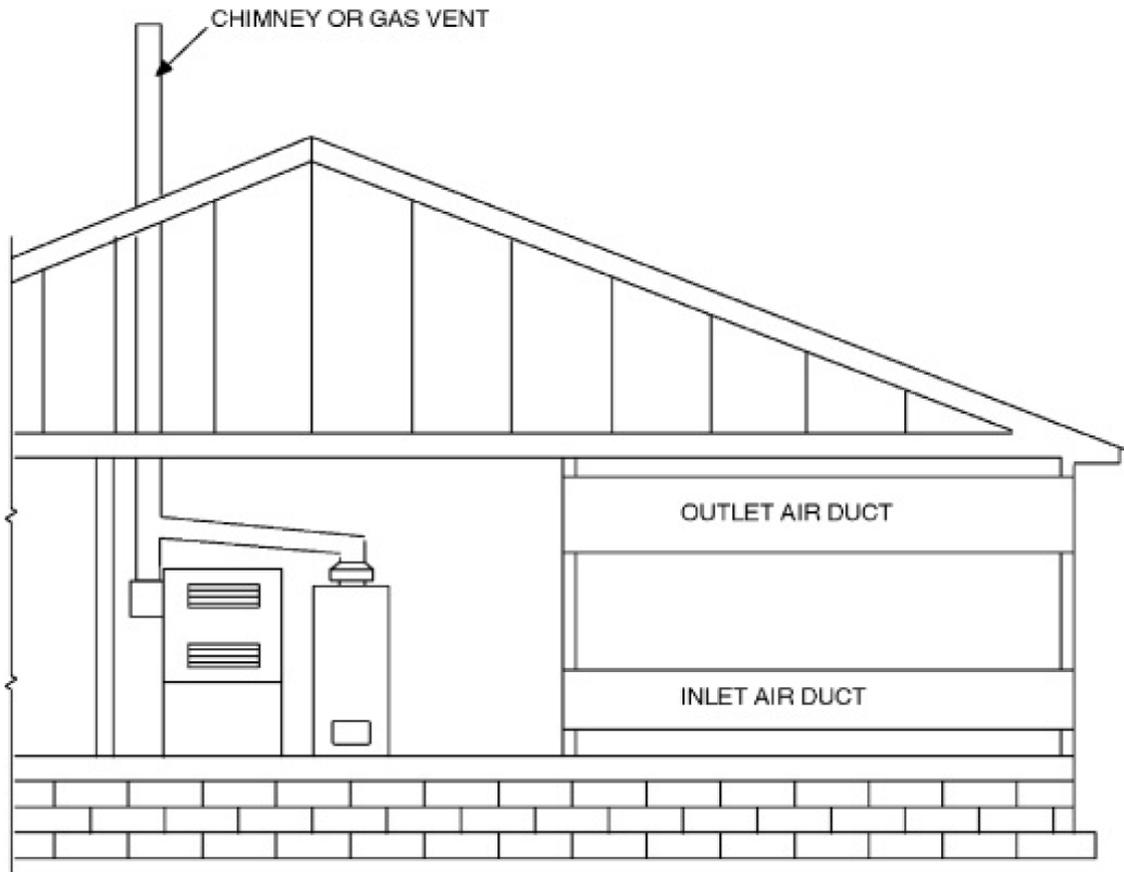


FIGURE G2407.6.1(3) [304.6.1(3)]

ALL AIR FROM OUTDOORS (see Section G2407.6.1)

G2407.6.2 (304.6.2) 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 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 through a vertical or horizontal duct to the outdoors, or spaces that freely communicate with the outdoors (see Figure G2407.6.2) and shall have a minimum free area of 1 square inch per 3,000 *Btu/h* (734 mm²/kW) of the total input rating of all *appliances* located in the enclosure and not less than the sum of the areas of all *vent connectors* in the space.

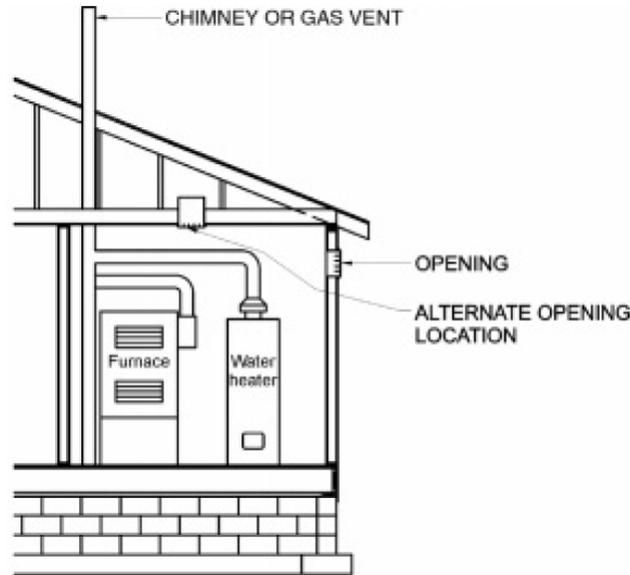


FIGURE G2407.6.2 (304.6.2)
SINGLE COMBUSTION AIR OPENING, ALL AIR FROM OUTDOORS (see Section G2407.6.2)

G2407.7 (304.7) Combination indoor and outdoor combustion air. The use of a combination of indoor and outdoor *combustion air* shall be in accordance with Sections G2407.7.1 through G2407.7.3.

G2407.7.1 (304.7.1) Indoor openings. Where used, openings connecting the interior spaces shall comply with Section G2407.5.3.

G2407.7.2 (304.7.2) Outdoor opening location. Outdoor opening(s) shall be located in accordance with Section G2407.6.

G2407.7.3 (304.7.3) Outdoor opening(s) size. The outdoor opening(s) size shall be calculated in accordance with the following:

1. The ratio of interior spaces shall be the available volume of all communicating spaces divided by the required volume.
2. The outdoor size reduction factor shall be one minus the ratio of interior spaces.
3. The minimum size of outdoor opening(s) shall be the full size of outdoor opening(s) calculated in accordance with Section G2407.6, multiplied by the reduction factor. The minimum dimension of air openings shall be not less than 3 inches (76 mm).

G2407.8 (304.8) Engineered installations. Engineered *combustion air* installations shall provide an adequate supply of *combustion, ventilation and dilution air* **determined using approved engineering methods.**

G2407.9 (304.9) Mechanical combustion air supply. Where all *combustion air* is provided by a mechanical air supply system, the *combustion air* shall be supplied from the outdoors at a rate not less than 0.35 cubic feet per minute per 1,000 *Btu/h* (0.034 m³/min per kW) of total input rating of all *appliances* located within the space.

G2407.9.1 (304.9.1) Makeup air. Where exhaust fans are installed, *makeup air* shall be provided to replace the exhausted air.

G2407.9.2 (304.9.2) Appliance interlock. Each of the *appliances* served shall be interlocked with the mechanical air supply system to prevent *main burner* operation when the mechanical air supply system is not in operation.

G2407.9.3 (304.9.3) Combined combustion air and ventilation air system. Where *combustion air* is provided by the building's mechanical ventilation system, the system shall provide the specified *combustion air* rate in addition to the required ventilation air.

G2407.10 (304.10) Louvers and grilles. The required size of openings for *combustion, ventilation and dilution air* shall be based on the net free area of each opening. Where the free area through a design of louver, grille or screen is

known, it shall be used in calculating the size opening required to provide the free area specified. Where the design and free area of louvers and grilles are not known, it shall be assumed that wood louvers will have 25-percent free area and metal louvers and grilles will have 75-percent free area. Screens shall have a mesh size not smaller than 1/4 inch (6.4 mm). Nonmotorized louvers and grilles shall be fixed in the open position. Motorized louvers shall be interlocked with the *appliance* so that they are proven to be 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 if the louvers fail to open during *burner* start-up and to shut down the *main burner* if the louvers close during operation.

G2407.11 (304.11) Combustion air ducts. *Combustion air* ducts shall comply with all of the following:

1. Ducts shall be constructed of galvanized steel complying with Chapter 16 or of 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 required fireblock is removed.

2. Ducts shall terminate in an unobstructed space allowing free movement of *combustion air* to the *appliances*.
3. Ducts shall serve a single enclosure.
4. Ducts shall not serve both upper and lower *combustion air* openings where both such openings are used. The separation between ducts serving upper and lower *combustion air* openings shall be maintained to the source of *combustion air*.
5. Ducts shall not be screened where terminating in an attic space.
6. Horizontal upper *combustion air* ducts shall not slope downward toward the source of *combustion air*.
7. The remaining space surrounding a *chimney* liner, gas vent, special gas vent or plastic *pipng* installed within a masonry, metal or factory-built *chimney* shall not be used to supply *combustion air*.

Exception: Direct-vent gas-fired *appliances* designed for installation in a solid fuel-burning *fireplace* where installed in accordance with the manufacturer's instructions.

8. *Combustion air* intake openings located on the exterior of a building shall have the lowest side of such openings located not less than 12 inches (305 mm) vertically from the adjoining finished ground level.

G2407.12 (304.12) Protection from fumes and gases. Where corrosive or flammable process fumes or gases, other than products of *combustion*, are present, means for the disposal of such fumes or gases shall be provided. Such fumes or gases include carbon monoxide, hydrogen sulfide, ammonia, chlorine and halogenated hydrocarbons.

In barbershops, beauty shops and other facilities where chemicals that generate corrosive or flammable products, such as aerosol sprays, are routinely used, nondirect vent-type *appliances* shall be located in a mechanical room separated or partitioned off from other areas with provisions for *combustion air* and *dilution air* from the outdoors. *Direct-vent appliances* shall be installed in accordance with the *appliance* manufacturer's instructions.

SECTION G2408 (305) INSTALLATION

G2408.1 (305.1) General. *Equipment* and *appliances* shall be installed as required by the terms of their approval, in accordance with the conditions of listing, the manufacturer's instructions and this code. Manufacturer's installation instructions shall be available on the job site at the time of inspection. Where a code provision is less restrictive than the conditions of the listing of the *equipment* or *appliance* or the manufacturer's installation instructions, the conditions of the listing and the manufacturer's installation instructions shall apply.

Unlisted *appliances approved* in accordance with Section G2404.3 shall be limited to uses recommended by the manufacturer and shall be installed in accordance with the manufacturer's instructions, the provisions of this code and the requirements determined by the *code official*.

G2408.2 (305.3) Elevation of ignition source. *Equipment* and *appliances* having an *ignition source* shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in *hazardous locations* and public garages, private garages, repair garages, motor fuel-dispensing facilities and parking garages. For the purpose of this section, rooms or spaces that are not part of the *living space* of a *dwelling unit* and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exception: Elevation of the *ignition source* is not required for *appliances* that are *listed* as flammable-vapor-ignition resistant.

G2408.2.1 (305.3.1) Installation in residential garages. In residential garages where *appliances* are installed 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 that the required *combustion air* is taken from the exterior of the garage.

G2408.3 (305.5) Private garages. *Appliances* located in private garages shall be installed with a minimum *clearance* of 6 feet (1829 mm) above the floor.

Exception: The requirements of this section shall not apply where the *appliances* are protected from motor vehicle impact and installed in accordance with Section G2408.2 and G2406.65.

G2408.4 (305.7) Clearances from grade. *Equipment* and *appliances* installed at grade level shall be supported on a level concrete slab or other *approved* material extending not less than 3 $\frac{1}{2}$ inches (76 mm) above adjoining grade or shall be suspended not less than 6 inches (152 mm) above adjoining grade. Such supports shall be installed in accordance with the manufacturer's instructions.

Under floor and exterior grade installations.

G2408.4.1 (305.7.1) Exterior grade installations. Equipment and appliances installed above grade level shall be supported on a solid base or on approved material that is a minimum of 2 inches (51 mm) thick.

G2408.4.2 (305.7.2) Under floor installation. Suspended equipment shall be a minimum of 6 inches (152 mm) above the adjoining grade.

G2408.4.3 (305.7.3) Crawl space supports. A support shall be provided at each corner of the unit not less than 8 inches by 8 inches (204 mm by 204 mm). The unit shall be supported a minimum of 2 inches (51 mm) above grade. When constructed of brick, the bricks shall be mortared together. All units stacked shall be mortared together. Fabricated units, formed concrete, or other approved materials shall be permitted.

G2408.4.4 (303.7) Pit Locations. Appliances installed in pits shall be installed in accordance with Section G2406.4.

G2408.4.5 (305.7.4) Drainage. Below grade installations shall be provided with a natural drain or an automatic lift or sump pump. For pit requirements, see Section G2406.4.

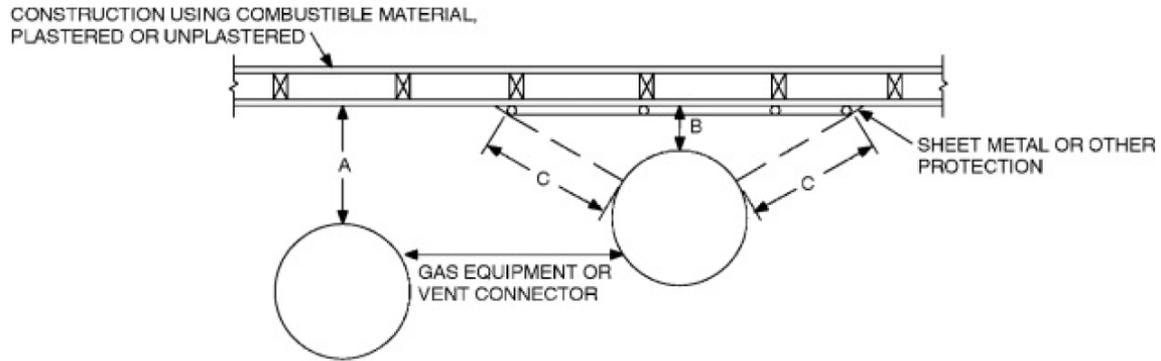
G2408.5 (305.8) Clearances to combustible construction. Heat-producing *equipment* and *appliances* shall be installed to maintain the required clearances to combustible construction as specified in the listing and manufacturer's instructions. Such *clearances* shall be reduced only in accordance with Section G2409. *Clearances* to combustibles shall include such considerations as door swing, drawer pull, overhead projections or shelving and window swing. Devices, such as door stops or limits and closers, shall not be used to provide the required *clearances*.

G2408.6 (305.12) Avoid strain on gas piping. *Appliances* shall be supported and connected to the *piping* so as not to exert undue strain on the connections.

SECTION G2409 (308) CLEARANCE REDUCTION

G2409.1 (308.1) Scope. This section shall govern the reduction in required clearances to *combustible materials*, including gypsum board, and *combustible assemblies* for chimneys, vents, *appliances*, devices and equipment. Clearance requirements for air-conditioning equipment and central heating boilers and furnaces shall comply with Sections G2409.3 and G2409.4.

G2409.2 (308.2) Reduction table. The allowable *clearance* reduction shall be based on one of the methods specified in Table G2409.2 or shall utilize a reduced *clearance* protective assembly *listed* and *labeled* in accordance with UL 1618. Where required *clearances* are not listed in Table G2409.2, the reduced clearances shall be determined by linear interpolation between the distances listed in the table. Reduced clearances shall not be derived by extrapolation below the range of the table. The reduction of the required clearances to combustibles for *listed* and *labeled appliances* and *equipment* shall be in accordance with the requirements of this section, except that such *clearances* shall not be reduced where reduction is specifically prohibited by the terms of the *appliance* or *equipment listing* [see Figures G2409.2(1) through 2409.2(3)].

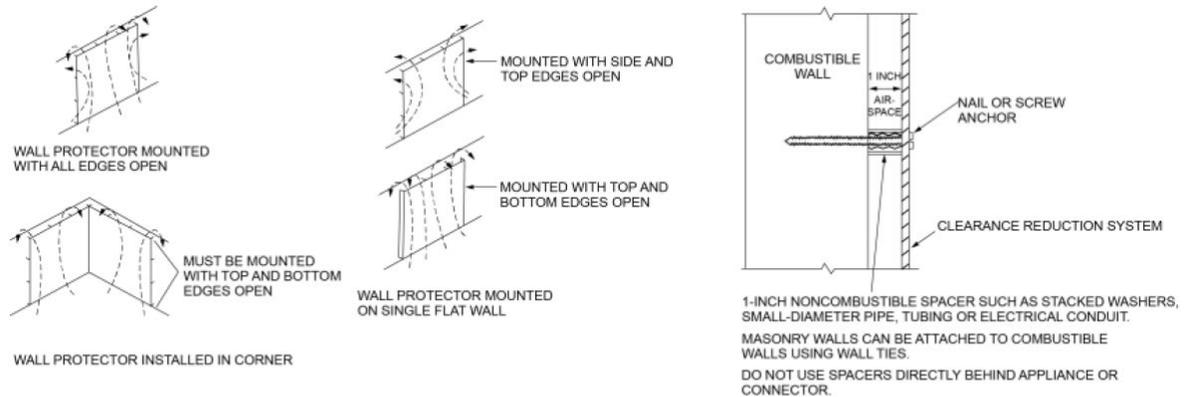


NOTES:

A = The clearance without protection.

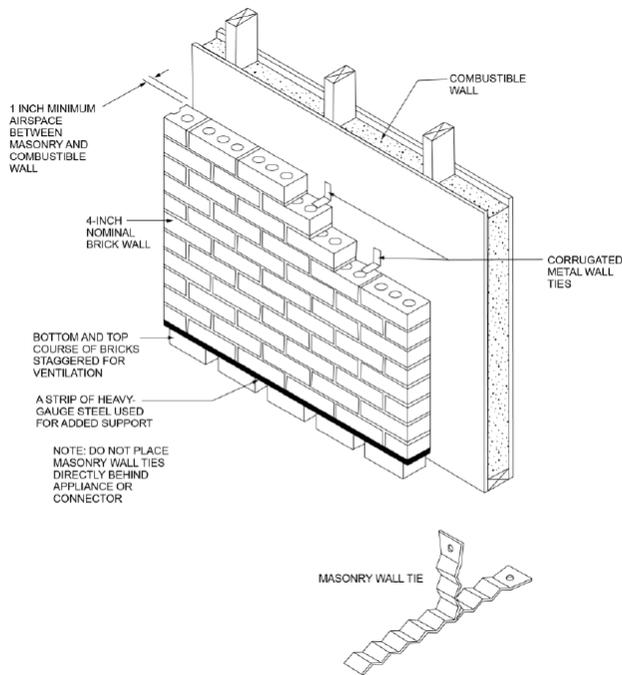
B = The reduced clearance permitted in accordance with **Table G2409.2**. The protection applied to the construction using combustible material shall extend far enough in each direction to make “C” equal to “A.”

FIGURE G2409.2(1) [308.2(1)]
EXTENT OF PROTECTION NECESSARY TO REDUCE CLEARANCES FROM GAS EQUIPMENT OR VENT CONNECTORS



For SI: 1 inch = 25.4 mm.

FIGURE G2409.2(2) [308.2(2)]
WALL PROTECTOR CLEARANCE REDUCTION SYSTEM



For SI: 1 inch = 25.4 mm.

FIGURE G2409.2(3) [308.2(3)]
MASONRY CLEARANCE REDUCTION SYSTEM

TABLE G2409.2 (308.2)
REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION^a through k

TYPE OF PROTECTION APPLIED TO AND COVERING ALL SURFACES OF COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION [see Figures G2409.2(1), G2409.2(2) and G2409.2(3)]	WHERE THE REQUIRED CLEARANCE WITH NO PROTECTION FROM APPLIANCE, VENT CONNECTOR OR SINGLE-WALL METAL PIPE IS: (inches)									
	36		18		12		9		6	
	Allowable clearances with specified protection (inches)									
	Use Column 1 for clearances above appliance or horizontal connector. Use Column 2 for clearances from appliance, vertical connector and single-wall metal pipe.									
	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2
1. 3½-inch-thick masonry wall without ventilated airspace	—	24	—	12	—	9	—	6	—	5
2. ½-inch insulation board over 1-inch glass fiber or mineral wool batts	24	18	12	9	9	6	6	5	4	3
3. 0.024-inch (nominal 24 gage) sheet metal over 1-inch glass fiber or mineral wool batts reinforced with wire on rear face with ventilated airspace	18	12	9	6	6	4	5	3	3	3
4. 3½-inch-thick masonry wall with ventilated airspace	—	12	—	6	—	6	—	6	—	6
5. 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace	18	12	9	6	6	4	5	3	3	2
6. ½-inch-thick insulation board with ventilated airspace	18	12	9	6	6	4	5	3	3	3

7. 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace over 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace	18	12	9	6	6	4	5	3	3	3
8. 1-inch glass fiber or mineral wool batts sandwiched between two sheets 0.024-inch (nominal 24 gage) sheet metal with ventilated airspace	18	12	9	6	6	4	5	3	3	3

For SI: 1 inch = 25.4 mm, °C = [(°F - 32)/1.8], 1 pound per cubic foot = 16.02 kg/m³, 1 Btu per inch per square foot per hour per °F = 0.144 W/m² × K.

- Reduction of clearances from combustible materials shall not interfere with combustion air, draft hood clearance and relief, and accessibility of servicing.
- Clearances shall be measured from the outer surface of the combustible material to the nearest point on the surface of the appliance, disregarding any intervening protection applied to the combustible material.
- Spacers and ties shall be of noncombustible material. A spacer or tie shall not be used directly opposite an appliance or connector.
- For all clearance reduction systems using a ventilated airspace, adequate provision for air circulation shall be provided as described [see Figures G2409.2(2) and G2409.2(3)].
- There shall be not less than 1 inch between clearance reduction systems and combustible walls and ceilings for reduction systems using ventilated airspace.
- Where a wall protector is mounted on a single flat wall away from corners, it shall have a minimum 1-inch air gap. To provide air circulation, the bottom and top edges, or only the side and top edges, or all edges shall be left open.
- Mineral wool batts (blanket or board) shall have a minimum density of 8 pounds per cubic foot and a minimum melting point of 1,500°F.
- Insulation material used as part of a clearance reduction system shall have a thermal conductivity of 1.0 Btu per inch per square foot per hour per °F or less.
- There shall be not less than 1 inch 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.
- Clearances and thicknesses are minimum; larger clearances and thicknesses are acceptable.
- Listed single-wall connectors shall be installed in accordance with the manufacturer's instructions.

G2409.3 (308.3) Clearances for indoor air-conditioning appliances. Clearance requirements for indoor air-conditioning appliances shall comply with Sections G2409.3.1 through G2409.3.4.

G2409.3.1 (308.3.1) Appliances clearances. Air-conditioning appliances shall be installed with clearances in accordance with the manufacturer's instructions.

G2409.3.2 (308.3.2) Clearance reduction. Air-conditioning appliances shall be permitted to be installed with reduced clearances to combustible material, provided that the combustible material or appliance is protected as described in Table G2409.2 and such reduction is allowed by the manufacturer's instructions.

G2409.3.3 (308.3.3) Plenum clearances. 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.

G2409.3.4 (308.3.4) Clearance from supply ducts. 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-foot (914 mm) distance.

G2409.4 (308.4) Central-heating boilers and furnaces. Clearance requirements for central-heating boilers and furnaces shall comply with Sections G2409.4.1 through G2409.4.5. The clearance to these appliances shall not interfere with combustion air, draft hood clearance and relief, and accessibility for servicing.

G2409.4.1 (308.4.1) Appliances clearances. Central-heating furnaces and low-pressure boilers shall be installed with clearances in accordance with the manufacturer's instructions.

G2409.4.2 (308.4.2) Clearance reduction. Central-heating furnaces and low-pressure boilers shall be permitted to be installed with reduced clearances to combustible material provided that the combustible material or appliance is protected as described in Table G2409.2 and such reduction is allowed by the manufacturer's instructions.

G2409.4.3 (308.4.3) Plenum clearances. 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.

G2409.4.4 (308.4.4) Clearance from supply ducts. 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-foot (914 mm) distance.

G2409.4.5 (308.4.3) Clearance for servicing appliances. Front *clearance* shall be sufficient for servicing the *burner* and the *furnace* or boiler.

SECTION G2410 (309) ELECTRICAL

G2410.1 (309.1) Grounding. *Gas piping* shall not be used as a grounding electrode.

G2410.2 (309.2) Connections. Electrical connections between *appliances* and the building wiring, including the grounding of the *appliances*, shall conform to ~~Chapters 34 through 43~~ *the North Carolina Electrical Code*.

SECTION G2411 (310) ELECTRICAL BONDING

G2411.1 (310.1) Pipe and tubing other than CSST. Each above-ground portion of a *gas piping system* other than corrugated stainless steel tubing (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 an *appliance* that is connected to the *equipment* grounding conductor of the circuit that supplies that *appliance*.

G2411.2 (310.2) CSST. This section applies to corrugated stainless steel tubing (CSST) that is not *listed* with an arc-resistant jacket or coating system in accordance with ANSI LC1/CSA 6.26. CSST *gas piping systems* and piping systems containing one or more segments of CSST shall be electrically continuous and bonded to the electrical service grounding electrode system or, where provided, the lightning protection grounding electrode system. ~~Corrugated stainless steel tubing (CSST) gas piping systems and piping systems containing one or more segments of CSST shall be bonded to the electrical service grounding electrode system.~~

Exception:

~~CSST with an arc-resistant jacket tested in accordance with ANSI LC 1, and listed by an *approved agency* for installation without the direct bonding, as prescribed in this section, shall be installed in accordance with Section G2411.1 and the manufacturer's installation instructions.~~

G2411.2.1 (310.2.1) Point of connection. The bonding jumper shall connect to a metallic pipe, pipe fitting or CSST fitting.

G2411.2.2 (310.2.2) Size and material of jumper. The bonding jumper shall be not smaller than 6 AWG copper wire or equivalent.

G2411.2.3 (310.2.3) Bonding jumper length. The length of the bonding jumper between the connection to a *gas piping system* and the connection to a grounding electrode system shall not exceed 75 feet (22 860 mm). Any additional grounding electrodes *installed to meet this requirement* shall be bonded to the electrical service grounding electrode system or, where provided, the lightning protection grounding electrode system.

G2411.2.4 (310.2.4) Bonding connections. Bonding connections shall be in accordance with NFPA 70.

G2411.2.5 (310.2.5) Connection devices. Devices used for making the bonding connections shall be *listed* for the application in accordance with UL 467.

G2411.3 (310.3) Arc-resistant CSST. This section applies to corrugated stainless steel tubing (CSST) that is *listed* with an arc-resistant jacket or coating system in accordance with ANSI LC1/CSA 6.26. The CSST shall be electrically continuous and bonded to an effective ground fault current path. Where any CSST component of a *piping system* does not have an arc-resistant jacket or coating system, the bonding requirements of Section G2411.2 shall apply. Arc-resistant-jacketed CSST shall be considered to be bonded where it is connected to an *appliance* that is connected to the *appliance* grounding conductor of the circuit that supplies that *appliance*.

SECTION G2412 (401) GENERAL

G2412.1 (401.1) Scope. This section shall govern the design, installation, modification and maintenance of *pipng systems*. The applicability of this *code* to *pipng systems* extends from the *point of delivery* to the connections with the *appliances* and includes the design, materials, components, fabrication, assembly, installation, testing, inspection, operation and maintenance of such *pipng systems*.

G2412.1.1 (401.1.1) Utility piping systems located within buildings. Utility service *pipng* located within buildings shall be installed in accordance with the structural safety and fire protection provisions of this code.

G2412.2 (401.2) Liquefied petroleum gas storage. ~~The storage system for liquefied petroleum gas shall be designed and installed in accordance with the International Fire Code and NFPA 58.~~ The enforcement of the location of undiluted liquefied petroleum gas containers shall be the responsibility of the North Carolina Department of Agriculture and Consumer Services in accordance with Article 5 of Chapter 119 of the North Carolina General Statutes.

G2412.3 (401.3) Modifications to existing systems. In modifying or adding to existing *pipng systems*, sizes shall be maintained in accordance with this chapter.

G2412.4 (401.4) Additional appliances. Where an additional *appliance* is to be served, the existing *pipng* shall be checked to determine if it has adequate capacity for all *appliances* served. If inadequate, the existing system shall be enlarged as required or separate *pipng* of adequate capacity shall be provided.

G2412.5 (401.5) Identification. For other than steel *pipe* and CSST, exposed *pipng* shall be identified by a yellow *label* marked "Gas" in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). The marking shall not be required on piping located in the same room as the *appliance* served. CSST shall be identified as required by ANSI LC1/CSA 6.26.

~~Exposed piping shall be identified by a yellow label marked "Gas" in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). All piping and tubing systems, greater than 0.5 pounds per square inch (3.45 kPa) service pressure, shall be identified by a yellow label with black letters indicating the piping system pressure. The system shall be marked at the beginning, all ends and at intervals not exceeding 5 feet (1524 mm) along its exposed length.~~

Exceptions:

- ~~1. Gas lines extending from the undiluted liquefied petroleum gas storage tanks to the building are not required to be labeled.~~
- ~~2. Black steel piping, 0.5 pounds per square inch (3.45 kPa) or less, located at dwelling units shall not be required to be labeled.~~

G2412.6 (401.6) Interconnections. Where two or more *meters* are installed on the same premises but supply separate consumers, the *pipng systems* shall not be interconnected on the outlet side of the *meters*.

G2412.7 (401.7) Piping meter identification. *Pipng* from multiple *meter* installations shall be marked with ~~an approved~~ permanent identification by the installer so that the *pipng system* supplied by each *meter* is readily identifiable.

G2412.8 (401.8) Minimum sizes. *Pipe* utilized for the installation, extension and *alteration* of any *pipng system* shall be sized to supply the full number of outlets for the intended purpose and shall be sized in accordance with Section G2413.

G2412.9 (401.9) Piping manufacturer Identification. Each length of pipe and tubing and each pipe fitting, utilized in a fuel gas system, shall bear the identification of the manufacturer.

Exceptions:

- Steel pipe sections that are 2 feet (610 mm) and less in length and are cut from longer sections of pipe.
- Steel pipe fittings 2 inches and less in size.
- Where identification is provided on the product packaging or crating.
- Where other *approved* documentation is provided.

G2412.10 (401.10) Piping materials standards. Piping, tubing and fittings shall be manufactured to the applicable referenced standards, specifications and performance criteria listed in Section G2414 and shall be identified in accordance with Section G2412.9. ~~Deleted.~~

G2412.911 Meter location. When required, a meter shall be provided for the building or residence to be served. The location shall be such that the meter can be read, serviced or changed. The location, space requirements, dimensions and proper clearances shall be acceptable to the local gas company.

SECTION G2413 (402) PIPE SIZING

G2413.1 (402.1) General considerations. Piping systems shall be of such size and so installed as to provide a supply of gas sufficient to meet the maximum demand and supply gas to each appliance inlet at not less than the minimum supply pressure required by the appliance.

G2413.2 (402.2) Maximum gas demand. The volumetric flow rate of gas to be provided shall be the sum of the maximum input of the appliances served.

The total connected hourly load shall be used as the basis for pipe sizing, assuming that all appliances could be operating at full capacity simultaneously. Where a diversity of load can be established, pipe sizing shall be permitted to be based on such loads.

The volumetric flow rate of gas to be provided shall be adjusted for altitude where the installation is above 2,000 feet (610 m) in elevation.

The volume of gas to be provided, in cubic feet per hour, (MBtu for undiluted propane), shall be determined directly from the manufacturer's input ratings of the appliances served. Where an input rating is not indicated, the gas supplier, appliance manufacturer or an approved agency shall be contacted. The total connected hourly load shall be used as the basis for pipe sizing, assuming that all appliances could be operating at full capacity simultaneously. Where a diversity of load can be established, pipe sizing shall be permitted to be based on such loads.

G2413.3 (402.3) Sizing. Gas piping shall be sized in accordance with one of the following:

1. Pipe sizing tables or sizing equations in accordance with Section G2413.4 or G2413.5, as applicable.
2. The sizing tables included in a listed piping system's manufacturer's installation instructions.
3. Approved engineering methods.

G2413.4 (402.4) Sizing tables and equations. This section applies to piping materials other than noncorrugated stainless steel tubing. Where Tables G2413.4(1) through G2413.4(2+23) are used to size piping or tubing, the pipe length shall be determined in accordance with Section G2413.4.1, G2413.4.2 or G2413.4.3.

Where Equations 24-3 and 24-4 are used to size piping or tubing, the pipe or tubing shall have smooth inside walls and the pipe length shall be determined in accordance with Section G2413.4.1, G2413.4.2 or G2413.4.3.

1. Low-pressure gas equation [less than 1½ pounds per square inch (psi) (10.3 kPa)]:

$$D = \frac{Q^{0.381}}{19.17 \left(\frac{\Delta H}{C_r \times L} \right)^{0.206}}$$

(Equation 24-3)

2. High-pressure gas equation [1½ psi (10.3 kPa) and above]:

$$D = \frac{Q^{0.381}}{18.93 \left[\frac{(P_1^2 - P_2^2) \times Y}{C_r \times L} \right]^{0.206}}$$

(Equation 24-4)

where:

- C_r = Value determined by Table G2413.4.
- D = Inside diameter of pipe, inches (mm).
- Q = Input rate appliance(s), cubic feet per hour at 60°F (16°C) 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.
- Y = Value determined by Table G2413.4.
- ΔH = Pressure drop, inch water column (27.7-inch water column = 1 psi).

TABLE G2413.4 (402.4)
 **C_r AND Y VALUES FOR NATURAL GAS AND
 UNDILUTED PROPANE AT STANDARD CONDITIONS**

GAS	EQUATION FACTORS	
	C_r	Y
Natural gas	0.6094	0.9992
Undiluted propane	1.2462	0.9910

For SI: 1 cubic foot = 0.028 m³, 1 foot = 305 mm,
 1-inch water column = 0.249 kPa,
 1 pound per square inch = 6.895 kPa,
 1 British thermal unit per hour = 0.293 W.

G2413.4.1 (402.4.1) 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.

G2413.4.2 (402.4.2) Branch length method. Pipe shall be sized as follows:

1. 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.

G2413.4.3 (402.4.3) 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.

G2413.5 (402.5) Noncorrugated stainless steel tubing. Noncorrugated stainless steel tubing shall be sized in accordance with Equations 24-3 and 24-4 of Section 2413.4 in conjunction with Section 2413.4.1, 2413.4.2 or 2413.4.3.

G2413.6 (402.6) Allowable pressure drop. The design pressure loss in any piping system under maximum demand, from the point of delivery to the inlet connection of all appliances served, shall be such that the supply pressure at each appliance inlet is greater than or equal to the minimum pressure required by the appliance.

G2413.7 (402.7) Maximum operating pressure. The maximum design operating pressure for piping systems located inside buildings shall not exceed 5 pounds per square inch gauge (psig) (34 kPa gauge) except where one or more of the following conditions are met:

1. The piping joints are welded or brazed.
2. The piping is joined by fittings listed to ANSI LC4/CSA 6.32 and installed in accordance with the manufacturer's instructions.
3. The piping joints are flanged and pipe-to-flange connections are made by welding or brazing.
4. The piping is located in a ventilated chase or otherwise enclosed for protection against accidental gas accumulation.
5. The piping is a temporary installation for buildings under construction.

G2413.7.1 (402.7.1) Operation below -5°F (-21°C). 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 prevent LP-gas vapor from condensing into a liquid.

SECTION G2414 (403) PIPING MATERIALS

G2414.1 (403.1) General. Materials used for *pipng systems* shall comply with the requirements of this chapter or shall be *approved*.

G2414.2 (403.2) Used materials. *Pipe*, fittings, *valves* or other materials shall not be used again unless they are free from foreign materials and have been ascertained to be adequate for the service intended. □

G2414.3 (403.3) Metallic pipe. Metallic *pipe* shall comply with Sections G2414.3.1 and G2414.3.2.

G2414.3.1 (403.3.1) Cast iron. Cast-iron *pipe* shall not be used.

G2414.3.2 (403.3.2) Steel. Steel, stainless steel and wrought-iron *pipe* shall not be lighter than Schedule 10 and shall comply with the dimensional standards of ASME B36.10M and one of the following standards:

1. ASTM A53/A53M.
2. ASTM A106.
3. ASTM A312.

G2414.4 (403.4) Metallic tubing. *Tubing* shall not be used with gases corrosive to the tubing material.

G2414.4.1 (403.4.1) Steel tubing. Steel *tubing* shall comply with ASTM A254.

G2414.4.2 (403.4.2) Stainless steel. Stainless steel *tubing* shall comply with ASTM A268 or ASTM A269.

G2414.4.3 (403.4.3) Copper or copper-alloy tubing. Copper *tubing* shall comply with Standard Type K or L of ASTM B88 or ASTM B280.

Copper and copper-alloy *tubing* shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas (0.7 milligrams per 100 liters).

G2414.4.4 (403.4.4) Corrugated stainless steel tubing. Corrugated stainless steel *tubing* shall be listed in accordance with ANSI LC1/CSA 6.26.

G2414.5 (403.5) Plastic pipe, tubing and fittings. Polyethylene plastic pipe, *tubing* and fittings used to supply fuel gas shall conform to ASTM D2513. Such pipe shall be marked "Gas" and "ASTM D2513."

Polyamide pipe, *tubing* and fittings shall be identified and conform to ASTM F2945. Such pipe shall be marked "Gas" and "ASTM F2945."

Polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) plastic pipe, *tubing* and fittings shall not be used to supply fuel gas.

G2414.5.1 (403.5.1) Anodeless risers. Plastic pipe, *tubing* and anodeless risers shall comply with the following:

1. 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.
2. 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 designed and certified to meet the requirements of Category I of ASTM D2513, and US Department of Transportation, Code of Federal Regulations, Title 49 CFR, Part 192.281(e). The manufacturer shall provide the user with qualified installation instructions as prescribed by the US Department of Transportation, Code of Federal Regulations, Title 49 CFR, Part 192.283(b).

G2414.5.2 (403.5.2) LP-gas systems. The use of plastic pipe, *tubing* and fittings in undiluted liquefied petroleum gas *pipng systems* shall be in accordance with NFPA 58.

G2414.5.3 (403.5.3) Regulator vent piping. Plastic pipe and fittings used to connect *regulator vents* to remote vent terminations shall be of PVC conforming to ANSI/UL 651. PVC vent *pipng* shall not be installed indoors.

G2414.6 (403.6) Workmanship and defects. *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. (See Section G2417.1.2.)

G2414.7 (403.7) 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. See Section G2415.6 for corrosion protection through an exterior wall, and Section G2415.11 for specific underground installations.

G2414.8 (403.8) Metallic pipe threads. Metallic *pipe* and fitting threads shall be taper *pipe* threads and shall comply with ASME B1.20.1.

G2414.8.1 (403.8.1) 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.

G2414.8.2 (403.8.2) Number of threads. Field threading of metallic *pipe* shall be in accordance with Table G2414.8.2.

TABLE G2414.8.2 (403.8.2)
SPECIFICATIONS FOR THREADING METALLIC PIPE

IRON PIPE SIZE (inches)	APPROXIMATE LENGTH OF THREADED PORTION (inches)	APPROXIMATE NO. OF THREADS TO BE CUT
1/2	3/4	10
3/4	3/4	10
1	7/8	10
1 1/4	1	11
1 1/2	1	11

For SI: 1 inch = 25.4 mm.

G2414.8.3 (403.8.3) Threaded joint sealing. Threaded joints shall be made using a thread joint sealing material. Thread joint sealing materials shall be nonhardening and shall be resistant to the chemical constituents of the gases to be conveyed through the *piping*. Thread joint sealing materials shall be compatible with the pipe and fitting materials on which the sealing materials are used.

G2414.9 (403.9) Metallic piping joints and fittings. The type of *piping* joint used shall be suitable 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 caused by the internal pressure and any additional forces caused by temperature expansion or contraction, vibration, fatigue, or to the weight of the *pipe* and its contents.

G2414.9.1 (403.9.1) Pipe joints. Schedule 40 and heavier *pipe* joints shall be threaded, flanged, brazed, welded or assembled with press-connect fittings listed in accordance with ANSI LC4/CSA 6.32. Pipe lighter than Schedule 40 shall be connected using press-connect fittings, flanges, brazing or welding. Where nonferrous *pipe* is brazed, the *brazing* materials shall have a melting point in excess of 1,000°F (538°C). *Brazing* alloys shall not contain more than 0.05-percent phosphorus. ~~Pipe joints shall be threaded, flanged, brazed, or welded, or made with press-connect fittings complying with ANSI LC 4. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05 percent phosphorus.~~

G2414.9.2 (403.9.2) Copper tubing joints. Copper *tubing* joints shall be assembled with approved gas tubing fittings, shall be brazed with a material having a melting point in excess of 1,000°F (538°C) or assembled with press-connect fittings listed in accordance with ANSI LC4/CSA 6.32. *Brazing* alloys shall not contain more than 0.05-percent phosphorus.

G2414.9.3 (403.9.3) Stainless steel tubing joints. Stainless steel *tubing* joints shall be welded, assembled with approved tubing fittings, brazed with a material having a melting point in excess of 1,000°F (538°C), or assembled with press-connect fittings listed in accordance with ANSI LC4/CSA 6.32.

G2414.9.4 (403.9.4) Flared joints. *Flared joints* shall be used only in systems constructed from nonferrous *pipe* and *tubing* where experience or tests have demonstrated that the joint is suitable for the conditions and where provisions are made in the design to prevent separation of the joints.

G2414.9.5 (403.9.5) Metallic fittings. Metallic fittings shall comply with the following:

1. Fittings used with steel, stainless steel or wrought-iron *pipe* shall be steel, stainless steel, copper alloy, malleable iron or cast iron.
2. Fittings used with copper or copper alloy *pipe* shall be copper or copper alloy.
3. Cast-iron bushings shall be prohibited.
4. Special fittings. Fittings such as couplings, proprietary-type joints, saddle tees, gland-type compression fittings, and flared, flareless and compression-type *tubing* fittings shall be: used within the fitting manufacturer's pressure-temperature recommendations; used within the service conditions anticipated with respect to vibration, fatigue, thermal expansion and contraction; and shall be *approved*.
5. ~~Where pipe fittings are drilled and tapped in the field, the operation shall be in accordance with all of the following:~~
 - 5.1. ~~The operation shall be performed on systems having operating pressures of 5 psi (34.5 kPa) or less.~~
 - 5.2. ~~The operation shall be performed by the gas supplier or the gas supplier's designated representative.~~
 - 5.3. ~~The drilling and tapping operation shall be performed in accordance with written procedures prepared by the gas supplier.~~
 - 5.4. ~~The fittings shall be located outdoors.~~
 - 5.5. ~~The tapped fitting assembly shall be inspected and proven to be free of leakage.~~

~~Deleted.~~

G2414.10 (403.10) Plastic piping, joints and fittings. Plastic *pipe*, *tubing* and fittings shall be joined in accordance with the manufacturers' instructions. Such joints shall comply with the following:

1. The joints shall be designed and installed so that the longitudinal pull-out resistance of the joint will be greater than or equal to the tensile strength of the plastic *piping* material.
2. 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 or stronger than the *pipe* or *tubing* being joined. Joints shall be made with the joining method recommended by the *pipe* manufacturer. Polyethylene heat fusion fittings shall be marked "ASTM D2513." Polyamide heat fusion fittings shall be marked "ASTM F2945."
3. 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 to or beyond the outside end of the compression fitting when installed. The stiffener shall be free of rough or sharp edges and shall not be a force-fit in the plastic. Split tubular stiffeners shall not be used.
4. Plastic *piping* joints and fittings for use in *liquefied petroleum gas piping systems* shall be in accordance with NFPA 58.

SECTION G2415 (404) PIPING SYSTEM INSTALLATION

G2415.1 (404.1) Installation of materials. Materials used shall be installed in strict accordance with the standards under which the materials are accepted and *approved*. In the absence of such installation procedures, the manufacturer's instructions shall be followed. Where the requirements of referenced standards or manufacturer's instructions do not conform to minimum provisions of this code, the provisions of this code shall apply.

G2415.2 (404.2) CSST. CSST piping systems shall be installed in accordance with the terms of their approval, the conditions of listing, the manufacturer's instructions and this code.

G2415.3 (404.3) Prohibited locations. *Piping* shall not be installed in or through a ducted supply, return or exhaust, or a clothes chute, *chimney* or gas vent, dumbwaiter or elevator shaft. *Piping* installed downstream of the *point of delivery* shall not extend through any townhouse unit other than the unit served by such *piping*.

G2415.4 (404.4) Piping in solid partitions and walls. *Concealed piping* shall not be located in solid partitions and solid walls, unless installed in a chase or casing.

G2415.5 (404.5) Fittings in concealed locations. Fittings installed in concealed locations shall be limited to the following types:

1. Threaded elbows, tees, couplings, plugs and caps.
2. Brazed fittings.
3. Welded fittings.
4. Fittings listed to ANSI LC1/CSA 6.26 or ANSI LC-4/CSA 6.32.

G2415.6 (404.6) Underground penetrations prohibited. ~~Gas piping shall not penetrate building foundation walls at any point below grade. Gas piping shall enter and exit a building at a point above grade and the annular space between the pipe and the wall shall be sealed.~~

Piping through foundation wall. Underground piping, where installed below grade through the outer foundation or basement wall of a building, shall be encased in a protective pipe sleeve, or shall be protected by an approved device or method. The annular space between the gas piping and the sleeve and between the sleeve and the wall shall be sealed.

G2415.7 (404.7) Protection against physical damage. Where piping will be concealed within light-frame construction assemblies, the piping shall be protected against penetration by fasteners in accordance with Sections G2415.7.1 through G2415.7.3.

Exception: Black steel piping and galvanized steel piping shall not be required to be protected.

G2415.7.1 (404.7.1) Piping through bored holes or notches. Where piping is installed through holes or notches in framing members and the piping is located less than 1½ inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the pipe shall be protected by shield plates that cover the width of the pipe and the framing member and that extend not less than 4 inches (102 mm) to each side of the framing member(s). Where the framing member that the piping passes through is a bottom plate, bottom track, top plate or top track, the shield plates shall cover the framing member and extend not less than 4 inches (102 mm) above the bottom framing member(s) and not less than 4 inches (102 mm) below the top framing member(s).

G2415.7.2 (404.7.2) Piping installed in other locations. Where the piping is located within a framing member (i.e. steel studs) and is less than 1½ inches (38 mm) from the framing member face to which wall, ceiling or floor membranes will be attached, the piping shall be protected by shield plates that cover the width and length of the piping. Where the piping is located outside of a framing member and is located less than 1½ inches (38 mm) from the nearest edge of the face of the framing member to which the membrane will be attached, the piping shall be protected by shield plates that cover the width and length of the piping.

2415.7.3 (404.7.3) Shield plates. Shield plates shall be of steel material having a thickness of not less than 0.0575 inch (1.463 mm) (No. 16 gage).

G2415.8 (404.8) Piping in solid floors. Piping in solid floors shall be laid in channels in the floor and covered in a manner that will allow access to the piping with a minimum amount of damage to the building. Where such piping is subject to exposure to excessive moisture or corrosive substances, the piping shall be protected in an approved manner. As an alternative to installation in channels, the piping shall be installed in a conduit of Schedule 40 steel, wrought iron, PVC or ABS pipe in accordance with Section G2415.8.1 or G2415.8.2.

G2415.8.1 (404.8.1) Conduit with one end terminating outdoors. The conduit shall extend into an occupiable portion of the building and, at the point where the conduit terminates in the building, the space between the conduit and the gas piping shall be sealed to prevent the possible entrance of any gas leakage. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor. If the end sealing is capable of withstanding the full pressure of the gas pipe, the conduit shall be designed for the same pressure as the pipe. Such conduit shall extend not less than 4 inches (102 mm) outside the building, shall be vented above grade to the outdoors and shall be installed so as to prevent the entrance of water and insects.

G2415.8.2 (404.8.2) 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. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.

G2415.9 (404.9) Above-ground piping outdoors. *Piping* installed outdoors shall be elevated not less than 3½ inches (89 mm) above ground and where installed across roof surfaces, shall be elevated not less than 3½ inches (89 mm) above the roof surface. *Piping* installed above ground, outdoors, and installed across the surface of roofs shall be securely supported and located where it will be protected from physical damage. Where passing through an outside wall, the *piping* shall be protected against corrosion by coating or wrapping with an inert material. Where *piping* is encased in a protective pipe sleeve, the annular space between the *piping* and the sleeve shall be sealed. Ferrous metal exposed in exterior locations shall be protected from corrosion with one coat of exterior paint. Zinc coatings (galvanized) shall be deemed adequate protection for *gas piping* above ground.

G2415.10 (404.10) Isolation. Metallic *piping* and metallic *tubing* that conveys *fuel gas* from an LP-gas storage container shall be provided with an *approved* dielectric fitting to electrically isolate the underground portion of the pipe or tube from the above-ground portion that enters a building. Such dielectric fitting or dielectric regulator shall be installed above ground, outdoors.

G2415.11 (404.11) Protection against corrosion underground. Steel pipe or *tubing* exposed to corrosive action, such as soil condition or moisture, shall be protected in accordance with Sections G2415.11.1 through G2415.11.4.

G2415.11.1 (404.11.1) Galvanizing. Zinc coating shall not be deemed adequate protection for underground *gas piping*.

G2415.11.2 (404.11.2) Protection methods. Underground piping shall comply with one or more of the following:

1. The piping shall be made of corrosion-resistant material that is suitable for the environment in which it will be installed.
2. Pipe shall have a factory-applied, electrically insulating coating. Fittings and joints between sections of coated pipe shall be coated in accordance with the coating manufacturer's instructions.
3. The piping shall have a cathodic protection system installed and the system shall be monitored and maintained in accordance with an *approved* program.

G2415.11.3 (404.11.3) Dissimilar metals. Where dissimilar metals are joined underground, an insulating coupling or fitting shall be used.

G2415.11.4 (404.11.4) Protection of risers. Steel risers connected to plastic piping shall be cathodically protected by means of a welded anode, except where such risers are anodeless risers. □

G2415.12 (404.12) Minimum burial depth. Underground *piping systems* shall be installed a minimum depth of 12 inches (305 mm) below grade, except as provided for in Sections G2415.12.1 and G2415.12.2.

G2415.12.1 (404.12.1) Individual outdoor appliances. Individual lines to outdoor lights, grills and other *appliances* shall be installed not less than 8 inches (203 mm) below finished grade, provided that such installation is *approved* and is installed in locations not susceptible to physical damage.

G2415.12.2 (404.12.2) Alternate to burial depth. Metal *piping* shall be provided with a protective conduit of wrought iron, plastic pipe, or steel pipe, and topped with a 3 inch (76 mm) thick by 6 inch (152 mm) wide concrete barrier. See Section G2415.17 for plastic gas pipe requirements and limitations.

G2415.13 (404.13) Trenches. The trench shall be graded so that the pipe has a firm, substantially continuous bearing on the bottom of the trench.

G2415.14 (404.14) Piping underground beneath buildings. *Piping* installed underground beneath buildings is prohibited except where the *piping* is encased in a conduit of wrought iron, plastic pipe, steel pipe, a piping or encasement system listed for installation beneath buildings, or other *approved* conduit material designed to withstand the superimposed loads. The conduit shall be protected from corrosion in accordance with Section G2415.11 and shall be installed in accordance with Section G2415.14.1 or G2415.14.2.

G2415.14.1 (404.14.1) Conduit with one end terminating outdoors. The conduit shall extend into an occupiable portion of the building and, at the point where the conduit terminates in the building, the space between the conduit and the *gas piping* shall be sealed to prevent the possible entrance of any gas leakage. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the *pipe* emerges from the floor. Where the end sealing is capable of withstanding the full pressure of the gas pipe, the conduit shall be designed for the same pressure as the pipe. Such conduit shall extend not less than 4 inches (102 mm) outside the building, shall be vented above grade to the outdoors and shall be installed so as to prevent the entrance of water and insects.

G2415.14.2 (404.14.2) 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. The conduit shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.

G2415.15 (404.15) Outlet closures. Gas *outlets* that do not connect to *appliances* shall be capped gastight.

Exception: *Listed* and *labeled* flush-mounted-type quick-disconnect devices and *listed* and *labeled* gas *convenience outlets* shall be installed in accordance with the manufacturer's instructions.

G2415.16 (404.16) Location of outlets. The unthreaded portion of *pipng outlets* shall extend not less than 1 inch (25 mm) through finished ceilings and walls and where extending through floors or outdoor patios and slabs, shall be not less than 2 inches (51 mm) above them. The *outlet* fitting or *pipng* shall be securely supported. *Outlets* shall not be placed behind doors. *Outlets* shall be located in the room or space where the *appliance* is installed.

Exception: *Listed* and *labeled* flush-mounted-type quick-disconnect devices and *listed* and *labeled* gas *convenience outlets* shall be installed in accordance with the manufacturer's instructions.

G2415.17 (404.17) Plastic pipe. The installation of plastic *pipe* shall comply with Sections G2415.17.1 through G2415.17.3.

G2415.17.1 (404.17.1) Limitations. Plastic pipe shall be installed outdoors underground only. Plastic pipe shall not be used within or under any building or slab or be operated at pressures greater than 100 psig (689 kPa) for natural gas or 30 psig (207 kPa) for LP-gas.

Exceptions:

1. Plastic pipe shall be permitted to terminate above ground outside of buildings where installed in premanufactured *anodeless risers* or service head adapter risers that are installed in accordance with the manufacturer's instructions.
2. Plastic pipe shall be permitted to terminate with a wall head adapter within buildings where the plastic pipe is inserted in a *pipng* material for *fuel gas* use in buildings.
3. Plastic pipe shall be permitted under outdoor patio, walkway and driveway slabs provided that the burial depth complies with Section G2415.12.

G2415.17.2 (404.17.2) Connections. Connections made outdoors and underground between metallic and plastic *pipng* shall be made only with transition fittings conforming to ASTM D2513 Category I or ASTM F1973.

G2415.17.3 (404.17.3) Tracer. A yellow-insulated copper tracer wire or other *approved* conductor, or a product specifically designed for that purpose, shall be installed adjacent to underground nonmetallic *pipng*. Access shall be provided to the tracer wire or the tracer wire shall terminate above ground at each end of the nonmetallic *pipng*. The tracer wire size shall be not less than 18 AWG and the insulation type shall be suitable for direct burial.

G2415.18 (404.18) Pipe debris removal. The interior of *pipng* shall be clear of debris. The use of a flammable or combustible gas to clean or remove debris from a *pipng system* shall be prohibited.

G2415.19 (404.19) Prohibited devices. A device shall not be placed inside the *pipng* or fittings that will reduce the cross-sectional area or otherwise obstruct the free flow of gas.

Exceptions:

1. *Approved* gas filters.
2. An *approved* fitting or device where the *gas pipng system* has been sized to accommodate the pressure drop of the fitting or device.

G2415.20 (404.20) Testing of pipng. Before any system of *pipng* is put in service or concealed, it shall be tested to ensure that it is gastight. Testing, inspection and purging of *pipng systems* shall comply with Section G2417.

**SECTION G2416 (405)
PIPING BENDS AND CHANGES IN DIRECTION**

G2416.1 (405.1) General. Changes in direction of pipe shall be permitted to be made by the use of fittings, factory bends or field bends.

G2416.2 (405.2) Metallic pipe. Metallic pipe bends shall comply with the following:

1. Bends shall be made only with bending tools and procedures intended for that purpose.
2. Bends shall be smooth and free from buckling, cracks or other evidence of mechanical damage.
3. The longitudinal weld of the pipe shall be near the neutral axis of the bend.
4. Pipe shall not be bent through an arc of more than 90 degrees (1.6 rad).
5. The inside radius of a bend shall be not less than six times the outside diameter of the pipe.

G2416.3 (405.3) 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 *pipng* manufacturer specifies the use of special bending tools or procedures, such tools or procedures shall be used.

SECTION G2417 (406) INSPECTION, TESTING AND PURGING

G2417.1 (406.1) General. Prior to acceptance and initial operation, all *pipng* installations shall be visually inspected and pressure tested to determine that the materials, design, fabrication and installation practices comply with the requirements of this code. (See-N.C.G.S. 143-139.3 for alternate Inspection of liquefied propane gas piping systems for residential structures.)

G2417.1.1 (406.1.1) Inspections. Inspection shall consist of visual examination, during or after manufacture, fabrication, assembly or *pressure tests*.

G2417.1.2 (406.1.2) Repairs and additions. In the event repairs or additions are made after the *pressure test*, the affected *pipng* 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 *approved* leak-detecting methods.

G2417.1.3 (406.1.3) New branches. Where new branches are installed to new *appliances*, only the newly installed branches shall be required to be *pressure tested*. Connections between the new *pipng* and the existing *pipng* shall be tested with a noncorrosive leak-detecting fluid or other *approved* leak-detecting methods.

G2417.1.4 (406.1.4) Section testing. A *pipng system* shall be permitted to be tested as a complete unit or in sections. A valve in a line shall not be used as a bulkhead between gas in one section of the *pipng system* and test medium in an adjacent section, except where a double block and bleed valve system is installed. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve-closing mechanism, is designed to safely withstand the test pressure.

G2417.1.5 (406.1.5) Regulators and valve assemblies. *Regulator* and valve assemblies fabricated independently of the *pipng system* in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication.

G2417.1.6 (406.1.6) Pipe clearing. Prior to testing, the interior of the pipe shall be cleared of all foreign material.

G2417.2 (406.2) Test medium. The test medium shall be air, nitrogen, carbon dioxide or an inert gas. Oxygen shall not be used as a test medium.

G2417.3 (406.3) Test preparation. *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*.

G2417.3.1 (406.3.1) Expansion joints. Expansion joints shall be provided with temporary restraints, if required, for the additional thrust load under test.

G2417.3.2 (406.3.2) Appliance and equipment isolation. *Appliances* and *equipment* that are not to be included in the test shall be either disconnected from the *pipng* or isolated by blanks, blind flanges or caps.

G2417.3.3 (406.3.3) Appliance and equipment disconnection. Where the *pipng 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 *pipng system* by disconnecting them and capping the *outlet(s)*.

G2417.3.4 (406.3.4) Valve isolation. Where the *pipng system* is connected to *appliances* or *equipment* designed for operating pressures equal to or greater than the test pressure, such *appliances* or *equipment* shall be isolated from the *pipng system* by closing the individual *appliance* or *equipment* shutoff valve(s).

G2417.3.5 (406.3.5) Testing precautions. Testing of *pipng* systems shall be performed in a manner that protects the safety of employees and the public during the test.

G2417.4 (406.4) Test pressure measurement. 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 caused by 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 greater than five times the test pressure.

G2417.4.1 (406.4.1) Test pressure. The test pressure to be used shall be not less than 1¹/₂ times the proposed maximum working pressure, but not less than ~~3 psig (20 kPa gauge)~~ 10 psig (69 kPa gauge), irrespective of design pressure. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the *pipng* greater than 50 percent of the specified minimum yield strength of the pipe.

Exception: Fuel *pipng* systems that are being tested with manifolds, regulators or other pressure regulating appliances in place at the time of the test shall be tested no less than one and one-half times the proposed maximum working pressure, but not less than 3 psig (20 kPa gauge), irrespective of design pressure.

G2417.4.2 (406.4.2) Test duration. The test duration shall be not less than 10 minutes.

G2417.4.2.1 (406.4.3) Test gauges. Gauges used for testing shall be as follows:

1. Tests requiring a pressure of 10 pounds per square inch (psi) (69 kPa) or less shall utilize a testing gauge having increments of 0.10 psi (0.69 kPa) or less.
2. Tests requiring a pressure of greater than 10 psi (69 kPa) but less than or equal to 100 psi (689 kPa) shall utilize a testing gauge having increments of 1 psi (6.9 kPa) or less.
3. Tests requiring a pressure of greater than 100 psi (689 kPa) shall utilize a testing gauge having increments of 2 psi (14 kPa) or less.

G2417.5 (406.5) Detection of leaks and defects. The *pipng system* shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak unless such reduction can be readily attributed to some other cause.

G2417.5.1 (406.5.1) Detection methods. 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 could provide a source of ignition shall not be used.

G2417.5.2 (406.5.2) Corrections. Where leakage or other defects are located, the affected portion of the *pipng system* shall be repaired or replaced and retested.

G2417.6 (406.6) Pipng system and equipment leakage check. Leakage checking of systems and *equipment* shall be in accordance with Sections G2417.6.1 through G2417.6.4.

G2417.6.1 (406.6.1) Test gases. Leak checks using fuel gas shall be permitted in *pipng systems* that have been pressure tested in accordance with Section G2417.

G2417.6.2 (406.6.2) Before turning gas on. During the process of turning gas on into a system of new *gas pipng*, the entire system shall be inspected to determine that there are no open fittings or ends and that all *valves* at unused outlets are closed and plugged or capped.

G2417.6.3 (406.6.3) 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 *pipng system* shall be checked for leakage. Where leakage is indicated, the gas supply shall be shut off until the necessary repairs have been made.

G2417.6.4 (406.6.4) Placing appliances and equipment in operation. *Appliances* and *equipment* shall not be placed in operation until after the *pipng system* has been checked for leakage in accordance with Section G2417.6.3, the *pipng system* has been purged in accordance with Section G2417.7 and the connections to the *appliances* have been checked for leakage.

G2417.7 (406.7) Purging. The purging of *pipng* shall be in accordance with Sections G2417.7.1 through 2417.7.3.

G2417.7.1 (406.7.1) Piping systems required to be purged outdoors. The purging of *piping systems* shall be in accordance with the provisions of Sections G2417.7.1.1 through G2417.7.1.4 where the *piping system* meets either of the following:

1. The design operating gas pressure is greater than 2 psig (13.79 kPa).
2. The *piping* being purged contains one or more sections of pipe or tubing meeting the size and length criteria of Table G2417.7.1.1.

G2417.7.1.1 (406.7.1.1) 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 to the outdoors in accordance with Section G2417.7.1.3. Where *gas piping* meeting the criteria of Table G2417.7.1.1 is removed from service, the residual fuel gas in the *piping* shall be displaced with an inert gas.

G2417.7.1.1 (406.7.1.1.1) Piping added to facilitate purging. Any *piping* added to facilitate purging to the outdoors shall be limited to the *piping* materials allowed and installed in accordance with Section G2414, or, if constantly attended, the temporary use of flexible hose complying with ANSI/UL 21 standard shall be used in accordance with NFPA 58.

Exception: If the line pressure cannot be vented to the outdoors, the building and all affected spaces shall be evacuated of personnel not involved with purging the gas lines. Quantities of flammable gas shall not exceed 25 percent of the lower explosive limit (1.0-percent fuel/air mixture for natural gas or 0.6-percent fuel/air mixture for LP-gas) as measured by a combustible gas detector, all ignition sources shall be eliminated, and adequate ventilation to prevent accumulation of flammable gases shall be provided.

**TABLE G2417.7.1.1 (406.7.1.1)
SIZE AND LENGTH OF PIPING**

NOMINAL PIPE SIZE (inches) ^a	LENGTH OF PIPING (feet)
≥ 2½ < 3	> 50
≥ 3 < 4	> 30
≥ 4 < 6	> 15
≥ 6 < 8	> 10
≥ 8	Any length

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

a. CSST EHD size of 62 is equivalent to nominal 2-inch pipe or tubing size.

G2417.7.1.2 (406.7.1.2) Placing in operation. Where *gas piping* containing air and meeting the criteria of Table G2417.7.1.1 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 G2417.7.1.3.

G2417.7.1.3 (406.7.1.3) Outdoor discharge of purged gases. The open end of a *piping* system being pressure vented or purged shall discharge directly to an outdoor location. Purging operations shall comply with all of the following requirements:

1. The point of discharge shall be controlled with a shutoff valve.
2. The point of discharge shall be located 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 complies with Section G2417.7.1.4.
4. Purging operations introducing fuel gas shall be stopped when 90 percent fuel gas by volume is detected within the pipe.
5. Persons not involved in the purging operations shall be evacuated from all areas within 10 feet (3048 mm) of the point of discharge.

G2417.7.1.4 (406.7.1.4) 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 zero percent to 100 percent in 1-percent or smaller increments.

G2417.7.2 (406.7.2) Piping systems allowed to be purged indoors or outdoors. The purging of *piping systems* shall be in accordance with the provisions of Section G2417.7.2.1 where the *piping system* meets both of the following:

1. The design operating gas pressure is 2 psig (13.79 kPa) or less.
2. The *piping* being purged is constructed entirely from pipe or tubing not meeting the size and length criteria of Table G2417.7.1.1.

G2417.7.2.1 (406.7.2.1) Purging procedure. The *piping system* shall be purged in accordance with one or more of the following:

1. The *piping* shall be purged with fuel gas and shall discharge to the outdoors.
2. The *piping* shall be purged with fuel gas and shall discharge to the indoors or outdoors through an *appliance* burner not located in a combustion chamber. Such burner shall be provided with a continuous source of ignition.
3. The *piping* shall be purged with fuel gas and shall discharge to the indoors or outdoors through a burner that has a continuous source of ignition and that is designed for such purpose.
4. The *piping* shall be purged with fuel gas that is discharged to the indoors or outdoors, and the point of discharge shall be monitored with a *listed* combustible gas detector in accordance with Section G2417.7.2.2. Purging shall be stopped when fuel gas is detected.
5. ~~The *piping* shall be purged by the gas supplier in accordance with written procedures.~~

G2417.7.2.2 (406.7.2.2) 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.

G2417.7.3 (406.7.3) Purging appliances and equipment. After the *piping system* has been placed in operation, *appliances* and *equipment* shall be purged before being placed into operation.

~~**G2417.7.4 (406.7.4) Personnel training.** Personnel performing purging operation shall be trained according to the hazards associated with purging and shall not rely on odor when monitoring the concentration of combustible gas.~~

SECTION G2418 (407) PIPING SUPPORT

G2418.1 (407.1) General. *Piping* shall be provided with support in accordance with Section G2418.2.

G2418.2 (407.2) Design and installation. *Piping* shall be supported with metal pipe hooks, metal pipe straps, metal bands, metal brackets, metal hangers or building structural components suitable for the size of *piping*, of adequate strength and quality, and located at intervals so as to prevent or damp out excessive vibration. *Piping* shall be anchored to prevent undue strains on connected *appliances* and shall not be supported by other *piping*. Pipe hangers and supports shall conform to the requirements of MSS SP-58 and shall be spaced in accordance with Section G2424. Supports, hangers and anchors shall be installed so as not to interfere with the free expansion and contraction of the *piping* between anchors. **The components** of the supporting *equipment* shall be designed and installed so that they will not be disengaged by movement of the supported *piping*.

SECTION G2419 (408) DRIPS AND SLOPED PIPING SEDIMENT TRAPS

G2419.1 (408.1) Slopes. *Piping* for other than dry gas conditions shall be sloped not less than $\frac{1}{4}$ inch in 15 feet (6.43 mm in 4572 mm) to prevent traps. ~~Deleted.~~

G2419.2 (408.2) Drips. Where wet gas exists, a *drip* shall be provided at any point in the line of pipe where *condensate* could collect. A *drip* shall also be provided at the outlet of the *meter* and shall be installed so as to constitute a trap

wherein an accumulation of *condensate* will shut off the flow of gas before the *condensate* will run back into the *meter*. Deleted.

G2419.3 (408.3) Location of drips. *Drips* shall be provided with *ready access* to permit cleaning or emptying. A *drip* shall not be located where the *condensate* is subject to freezing. Deleted.

G2419.4 (408.4) Sediment trap. Where a sediment trap is not incorporated as 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. The sediment trap shall be either a tee fitting having a capped nipple of any length installed vertically in the bottommost opening of the tee as illustrated in Figure G2419.4 or other device *approved* as an effective sediment trap. Illuminating *appliances*, ranges, clothes dryers, *log lighters*, *gas logs*, decorative vented *appliances* for installation in vented fireplaces, gas fireplaces and outdoor grills need not be so equipped. The sediment trap required by a *MP regulator* can act as the Section G2419.4 required sediment trap, (see Section G2419.4, Item 5), if it is located within 6 feet (nominal) of the *appliance*.

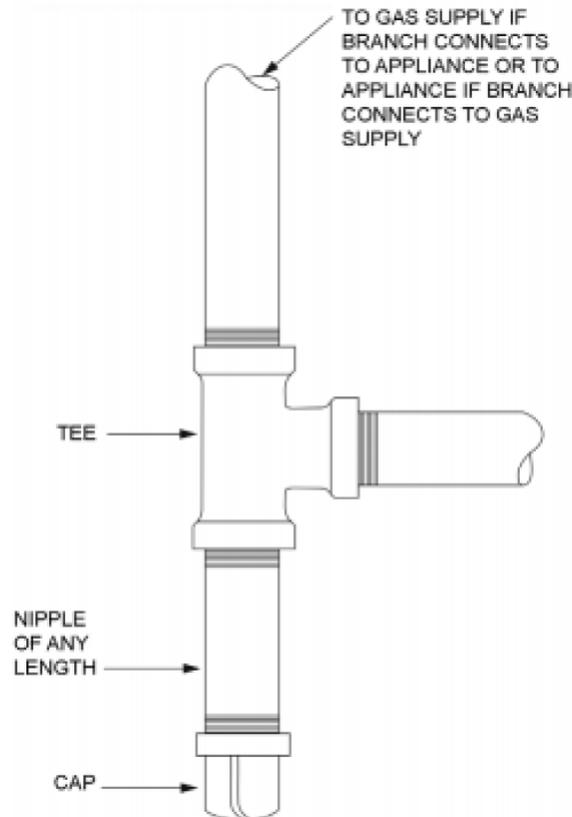


FIGURE G2419.4 (408.4)
METHOD OF INSTALLING A TEE FITTING SEDIMENT TRAP

SECTION G2420 (409) **SHUTOFF VALVES**

G2420.1 (409.1) General. *Piping systems* shall be provided with shutoff valves in accordance with this section.

G2420.1.1 (409.1.1) Valve approval. Shutoff valves shall be of an *approved* type; shall be constructed of materials compatible with the *piping*; and shall comply with the standard that is applicable for the pressure and application, in accordance with Table G2420.1.1.

TABLE G2420.1.1 (409.1.1)
MANUAL GAS VALVE STANDARDS

VALVE STANDARDS	APPLIANCE SHUTOFF VALVE APPLICATION UP TO 1/2 psig PRESSURE	OTHER VALVE APPLICATIONS			
		UP TO 1/2 psig PRESSURE	UP TO 2 psig PRESSURE	UP TO 5 psig PRESSURE	UP TO 125 psig PRESSURE
ANSI Z21.15/CGA 9.1	X	—	—	—	—
ASME B16.44	X	X	X ^a	X ^b	—
ASME B16.33	X	X	X	X	X

For SI: 1 pound per square inch gauge = 6.895 kPa.

a. If labeled 2G.

b. If labeled 5G.

G2420.1.2 (409.1.2) Prohibited locations. Shutoff valves shall be prohibited in *concealed locations* and *furnace plenums*.

G2420.1.3 (409.1.3) Access to shutoff valves. Shutoff *valves* shall be located in places so as to provide access for operation and shall be installed so as to be protected from damage.

G2420.2 (409.2) Meter valve. ~~Every *meter* shall be equipped with a shutoff valve located on the supply side of the meter.~~ Deleted.

G2420.3 (409.3.2) Individual buildings. In a common system serving more than one building, shutoff valves shall be installed outdoors at each building.

G2420.4 (409.4) MP regulator valves. A *listed* shutoff valve shall be installed immediately ahead of each MP *regulator*.

G2420.5 (409.5) Appliance shutoff valve. Each *appliance* shall be provided with a shutoff valve in accordance with Section G2420.5.1, G2420.5.2 or G2420.5.3.

G2420.5.1 (409.5.1) Located within same room. The shutoff valve shall be located in the same room as the *appliance*. The shutoff valve shall be within 6 feet (1829 mm) of the *appliance*, and shall be installed upstream of the union, connector or quick disconnect device it serves. Such shutoff *valves* shall be provided with *access*. **Shutoff valves serving movable *appliances*, such as cooking *appliances* and clothes dryers, shall be considered to be provided with access where installed behind such *appliances*.** *Appliance shutoff valves* located in the firebox of a *fireplace* shall be installed in accordance with the *appliance* manufacturer's instructions. **This section shall not prohibit the use or the installation of gas shutoff valves in the firebox of *fireplaces* serving *listed* gas *appliances*.**

G2420.5.2 (409.5.2) Vented decorative appliances and room heaters. Shutoff valves for vented decorative *appliances*, room heaters and decorative *appliances* for installation in vented *fireplaces* shall be permitted to be installed in an area remote from the *appliances* where such valves are provided with *ready access*. Such *valves* shall be permanently identified and shall not serve another *appliance*. The *pipng* from the shutoff valve to within 6 feet (1829 mm) of the *appliance* shall be designed, sized and installed in accordance with Sections G2412 through G2419.

G2420.5.3 (409.5.3) Located at manifold. ~~Where the *appliance* shutoff valve is installed at a manifold, such shutoff valve shall be located within 50 feet (15 240 mm) of the *appliance* served and shall be readily accessible and permanently identified. The *pipng* from the manifold to within 6 feet (1829 mm) of the *appliance* shall be designed, sized and installed in accordance with Sections G2412 through G2419.~~ Deleted.

G2420.6 (409.7) Shutoff valves in tubing systems. Shutoff valves installed in *tubing* systems shall be rigidly and securely supported independently of the *tubing*.

SECTION G2421 (410)
FLOW CONTROLS

G2421.1 (410.1) Pressure regulators. A line *pressure regulator* shall be installed where the *appliance* is designed to operate at a lower pressure than the supply pressure. *Line gas pressure regulators* shall be *listed* as complying with

ANSI Z21.80/CSA 6.22. Access shall be provided to *pressure regulators*. *Pressure regulators* shall be protected from physical damage. *Regulators* installed on the exterior of the building shall be *approved* for outdoor installation.

G2421.2 (410.2) MP regulators. MP *pressure regulators* shall comply with the following:

1. The MP *regulator* shall be *approved* and shall be suitable for the inlet and outlet gas pressures for the application.
2. The MP *regulator* shall maintain a reduced outlet pressure under lock-up (no-flow) conditions.
3. The capacity of the MP *regulator*, determined by published ratings of its manufacturer, shall be adequate to supply the *appliances* served.
4. The MP *pressure regulator* shall be provided with *access*. Where located indoors, the *regulator* shall be vented to the outdoors or shall be equipped with a leak-limiting device, in either case complying with Section G2421.3.
5. A tee fitting with one opening capped or plugged shall be installed between the MP *regulator* and its upstream shutoff valve. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument and to serve as a sediment trap.
6. A tee fitting with one opening capped or plugged shall be installed not less than 10 pipe diameters downstream of the MP *regulator* outlet. Such tee fitting shall be positioned to allow connection of a pressure-measuring instrument. The tee fitting is not required where the MP *regulator* serves an *appliance* that has a pressure test port on the gas control inlet side and the *appliance* is located in the same room as the MP *regulator*. ~~A means to test pressure shall be installed not less than 10 pipe diameters downstream of the MP *regulator* outlet. Such fitting shall be positioned to allow connection of a pressure-measuring instrument.~~
7. Where connected to rigid *pipng*, a union shall be installed within 1 foot (304 mm) of either side of the MP *regulator*.

Exception: Where other than rigid *pipng* is connected to the MP *regulator*, the union is not required.

G2421.3 (410.3) Venting of regulators. *Pressure regulators* that require a vent shall be vented directly to the outdoors. The vent shall be designed to prevent the entry of insects, water and foreign objects. Vents shall terminate not less than 3 feet (914 mm) from a possible source of ignition.

Exception: A vent to the outdoors is not required for *regulators* equipped with and *labeled* for utilization with an *approved* vent-limiting device installed in accordance with the manufacturer's instructions.

1. ~~Regulator vent outlets serving propane piping shall be located 3 feet (914 mm) horizontally from openings and operable openings that are below the vent, and 5 feet (1525 mm) in any direction from direct vent appliance intakes and mechanical ventilation intakes or 1 foot (305 mm) below openings and operable openings, and 3 feet (914 mm) below direct vent and mechanical vent intakes.~~
2. ~~Regulator vent outlets serving natural gas piping shall be located 3 feet (914 mm) horizontally from operable openings above the vent, and 5 feet (1525 mm) horizontally from direct vent appliance intakes and mechanical ventilation air intakes located above the vent, or 1 foot (305 mm) above openings and operable openings, and 3 feet (914 mm) above direct vent and mechanical vent intakes.~~

G2421.3.1 (410.3.1) Vent piping. Vent *pipng* for relief vents and breather vents shall be constructed of materials allowed for *gas pipng* in accordance with Section G2414. Vent *pipng* shall be not smaller than the vent connection on the pressure-regulating device. Vent *pipng* serving relief vents and combination relief and breather vents shall be run independently to the outdoors and shall serve only a single device vent. Vent *pipng* serving only breather vents is permitted to be connected in a manifold arrangement where sized in accordance with an *approved* design that minimizes backpressure in the event of diaphragm rupture. *Regulator* vent *pipng* shall not exceed the length specified in the *regulator* manufacturer's instructions.

G2421.4 (410.4) Excess flow valves. Where automatic *excess flow valves* are installed, they shall be *listed* in accordance with ANSI Z21.93/CSA 6.30 and shall be sized and installed in accordance with the manufacturer's instructions.

G2421.5 (410.5) Flashback arrestor check valve. Where fuel gas is used with oxygen in any hot work operation, a *listed* protective device that serves as a combination flashback arrestor and backflow check valve shall be installed at an *approved* location on both the fuel gas and oxygen supply lines. Where the pressure of the piped fuel gas supply is insufficient to ensure such safe operation, *approved* equipment shall be installed between the gas meter and the *appliance* that increases pressure to the level required for such safe operation.

G2421.6 (416) Overpressure protection devices.

G2421.6.1 (416.1) Where required. Where the serving gas supplier delivers gas at a pressure greater than 2 psi for pipng systems serving appliances designed to operate at a gas pressure of 14 inches w.c. or less, overpressure protection devices shall be installed. Pipng systems serving equipment designed to operate at inlet pressures greater than 14 inches w.c. shall be equipped with overpressure protection devices as required by the appliance manufacturer's installation instructions.

G2421.6.2 (416.2) Pressure limitation requirements. The requirements for pressure limitation shall be in accordance with Sections G2421.6.2.1 through G2421.6.2.5.

G2421.6.2.1 (416.2.1) Pressure under 14 inches w.c. Where pipng systems serving appliances designed to operate with a gas supply pressure of 14 inches w.c. or less are required to be equipped with overpressure protection by Section ~~416~~G2421.6.1, each overpressure protection device shall be adjusted to limit the gas pressure to each connected appliance to 2 psi or less upon a failure of the line pressure regulator.

G2421.6.2.2 (416.2.2) Pressure over 14 inches w.c. Where pipng systems serving appliances designed to operate with a gas supply pressure greater than 14 inches w.c. are required to be equipped with overpressure protection by Section G2421.6.1, each overpressure protection device shall be adjusted to limit the gas pressure to each connected appliance as required by the appliance manufacturer's installation instructions.

G2421.6.2.3 (416.2.3) Device capability. Each overpressure protection device installed to meet the requirements of this section shall be capable of limiting the pressure to its connected appliance(s) as required by this Section G2421.6.2.1, independently of any other pressure control equipment in the pipng system.

G2421.6.2.4 (416.2.4) Failure detection. Each gas pipng system for which an overpressure protection device is required by Section G2421.6 shall be designed and installed so that a failure of the primary pressure control device(s) is detectable.

G2421.6.2.5 (416.2.5) Relief valve. Where a pressure relief valve is used to meet the requirements of Section G2421.6, it shall have a flow capacity such that the pressure in the protected system is maintained at or below the limits specified in Section G2421.6.2.1 under all of the following conditions:

1. The line pressure regulator for which the relief valve is providing overpressure protection has failed wide open.
2. The gas pressure at the inlet of the line pressure regulator for which the relief valve is providing over-pressure protection is not less than the regulator's normal operating inlet pressure.

G2421.6.3 (416.3) ~~Devices~~Overpressure protection devices. ~~Pressure relieving or pressure limiting~~Overpressure protection devices shall be one of the following:

1. Pressure relief valve.
2. Monitoring regulator.
3. Series regulator installed upstream from the line regulator and set to continuously limit the pressure on the inlet of the line regulator to the maximum values specified by Section G2421.6.2.1.
4. Automatic shutoff device installed in series with the line pressure regulator and set to shut off when the pressure on the downstream pipng system reaches the maximum values specified by Section G2421.6.2.1. This device shall be designed so that it will remain closed until manually reset.

The devices specified in this section shall be installed either as an integral part of the service or line pressure regulator or as separate units. Where separate ~~pressure relieving or pressure limiting~~overpressure protection devices are installed, they shall comply with Sections G2421.6.3.1 through G2421.6.3.6.

G2421.6.3.1 (416.3.1) Construction and installation. ~~Pressure relieving and pressure limiting~~Overpressure protection devices shall be constructed of materials so that the operation of the devices will not be impaired by corrosion of external parts by the atmosphere or of internal parts by the gas. ~~Pressure relieving and pressure limiting~~Overpressure protection devices shall be designed and installed so that they can be operated to determine whether the valve is free. The devices shall be designed and installed so that they can be tested to determine the pressure at which they will operate and examined for leakage when in the closed position.

G2421.6.3.2 (416.3.2) External control piping. External control *piping* shall be designed and installed so that damage to the control *piping* of one device will not render both the regulator and the overpressure protection device inoperative.

G2421.6.3.3 (416.3.3) Setting. Each ~~pressure relieving or pressure limiting~~overpressure protection device shall be set so that the gas pressure supplied to the connected *appliances* does not exceed the limits specified in Sections G2421.6.2.1 and G2421.6.2.2.

G2121.6.3.4 (416.3.4) Unauthorized operation. Where unauthorized operation of any shutoff valve could render a ~~pressure relieving valve or pressure limiting~~an overpressure protection device inoperative, one of the following shall be accomplished:

1. The valve shall be locked in the open position. Authorized personnel shall be instructed in the importance of leaving the shutoff valve open and of being present while the shutoff valve is closed so that it can be locked in the open position before leaving the premises.

2. Duplicate relief valves shall be installed, each having adequate capacity to protect the system, and the isolating valves and three-way valves shall be arranged so that only one relief valve can be rendered inoperative at a time.

G2421.6.3.5 (416.3.5) Vents. The discharge stacks, vents and outlet parts of all ~~pressure relieving and pressure limiting~~overpressure protection devices shall be located so that gas is safely discharged to the outdoors. Discharge stacks and vents shall be designed to prevent the entry of water, insects and 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.

G2421.6.3.6 (416.3.6) Size of fittings, pipe and openings. The fittings, pipe and openings located between the system to be protected and the pressure-relieving device shall be sized to prevent hammering of the valve and to prevent impairment of relief capacity.

SECTION G2422 (411) APPLIANCE CONNECTIONS

G2422.1 (411.1) Connecting appliances. *Appliances* shall be connected to the *piping system* by one of the following:

1. Rigid metallic pipe and fittings.
2. Corrugated stainless steel *tubing* (CSST) where installed in accordance with the manufacturer's instructions.
3. *Listed* and *labeled* *appliance connectors* in compliance with ANSI Z21.24/CSA 6.10 and installed in accordance with the manufacturer's instructions and located entirely in the same room as the *appliance*.
4. *Listed* and *labeled* quick-disconnect devices in compliance with ANSI Z21.41/CSA 6.9 used in conjunction with *listed* and *labeled* *appliance connectors*.
5. *Listed* and *labeled* convenience outlets in compliance with ANSI Z21.90/CSA 6.24 used in conjunction with *listed* and *labeled* *appliance connectors*.
6. *Listed* and *labeled* outdoor *appliance connectors* in compliance with ANSI Z21.75/CSA 6.27 and installed in accordance with the manufacturer's instructions.
7. *Listed* outdoor gas hose connectors in compliance with ANSI Z21.54 used to connect portable outdoor *appliances*. The gas hose connection shall be made only in the outdoor area where the *appliance* is used, and shall be to the gas *piping* supply at an *appliance* shutoff valve, a *listed* quick-disconnect device or *listed* gas convenience outlet.

G2422.1.1 (411.1.2) Protection from damage. Connectors and *tubing* shall be installed so as to be protected against physical damage.

G2422.1.2 (411.1.3) Connector installation. *Appliance* fuel connectors shall be installed in accordance with the manufacturer's instructions and Sections G2422.1.2.1 through G2422.1.2.4.

G2422.1.2.1 (411.1.3.1) Maximum length. Connectors shall have an overall length not to exceed 6 feet (1829 mm). Measurement shall be made along the centerline of the connector. Only one connector shall be used for each *appliance*.

Exception: Rigid metallic *pipng* used to connect an *appliance* to the *pipng system* shall be permitted to have a total length greater than 6 feet (1829 mm), provided that the connecting pipe is sized as part of the *pipng system* in accordance with Section G2413 and the location of the *appliance* shutoff valve complies with Section G2420.5.

G2422.1.2.2 (411.1.3.2) Minimum size. Connectors shall have the capacity for the total *demand* of the connected *appliance*.

G2422.1.2.3 (411.1.3.3) Prohibited locations and penetrations. Connectors shall not be concealed within, or extended through, walls, floors, partitions, ceilings or *appliance* housings.

Exceptions:

1. Connectors constructed of materials allowed for *pipng systems* in accordance with Section G2414 shall be permitted to pass through walls, floors, partitions and ceilings where installed in accordance with Section G2420.5.2 ~~or G2420.5.3~~.
2. Rigid steel pipe connectors shall be permitted to extend through openings in *appliance* housings.
3. *Fireplace* inserts that are factory equipped with grommets, sleeves or other means of protection in accordance with the listing of the *appliance*.
4. Semirigid *tubing* and *listed* connectors shall be permitted to extend through an opening in an *appliance* housing, cabinet or casing where the tubing or connector is protected against damage.

G2422.1.2.4 (411.1.3.4) Shutoff valve. A shutoff valve not less than the nominal size of the connector shall be installed ahead of the connector in accordance with Section G2420.5.

G2422.1.3 (411.1.5) Connection of gas engine-powered air conditioners. Internal combustion engines shall not be rigidly connected to the gas supply *pipng*.

G2422.1.4 (411.1.6) Unions. A union fitting shall be provided for *appliances* connected by rigid metallic pipe. Such unions shall be accessible and located within 6 feet (1829 mm) of the *appliance*.

G2422.1.5 (411.1.4) Movable appliances. Where *appliances* are equipped with casters or are otherwise subject to periodic movement or relocation for purposes such as routine cleaning and maintenance, such *appliances* shall be connected to the supply system *pipng* by means of an *appliance connector listed* as complying with ANSI Z21.69/CSA 6.16 or by means of Item 1 of Section G2422.1. Such flexible connectors shall be installed and protected against physical damage in accordance with the manufacturer's instructions.

G2422.2 (411.3) Suspended low-intensity infrared tube heaters. Suspended low-intensity infrared tube heaters shall be connected to the building *pipng system* with a connector *listed* for the application complying with ANSI Z21.24/CSA 6.10. The connector shall be installed as specified by the tube heater manufacturer's instructions.

**SECTION G2423 (413)
COMPRESSED NATURAL GAS MOTOR
VEHICLE FUEL-DISPENSING FACILITIES**

G2423.1 (413.1) General. Motor fuel-dispensing facilities for CNG fuel shall be in accordance with Section 413 of the *International Fuel Gas Code*.

**SECTION G2424 (415)
PIPING SUPPORT INTERVALS**

G2424.1 (415.1) Interval of support. *Pipng* shall be supported at intervals not exceeding the spacing specified in Table G2424.1. Spacing of supports for CSST shall be in accordance with the CSST manufacturer's instructions.

Exception: Fuel gas pipng from grade-mounted propane tanks, less than 2000 gallon w.c., extending from the tank into the ground, or into the building with less than 4 feet (1219 mm) of pipe shall not require additional support.

**TABLE G2424.1 (415.1)
SUPPORT OF PIPING**

STEEL PIPE, NOMINAL SIZE OF PIPE (inches)	SPACING OF SUPPORTS (feet)	NOMINAL SIZE OF TUBING SMOOTH-WALL (inch O.D.)	SPACING OF SUPPORTS (feet)
1/2	6	1/2	4
3/4 or 1	8	5/8 or 3/4	6
1 1/4 or larger (horizontal)	10	7/8 or 1 (horizontal)	8
1 1/4 or larger (vertical)	Every floor level	1 or larger (vertical)	Every floor level

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

SECTION G2425 (501) GENERAL

G2425.1 (501.1) Scope. This section shall govern the installation, maintenance, repair and approval of factory-built *chimneys*, *chimney* liners, vents and connectors and the utilization of masonry chimneys serving gas-fired *appliances*.

G2425.2 (501.2) General. Every *appliance* shall discharge the products of combustion to the outdoors, except for *appliances* exempted by Section G2425.8.

G2425.3 (501.3) Masonry chimneys. *Masonry chimneys* shall be constructed in accordance with Section G2427.5 and Chapter 10.

G2425.4 (501.4) Minimum size of chimney or vent. *Chimneys* and vents shall be sized in accordance with Sections G2427 and G2428. Examples of methodologies are shown in Appendix B.

G2425.5 (501.5) Abandoned inlet openings. Abandoned inlet openings in *chimneys* and vents shall be closed by an *approved* method.

G2425.6 (501.6) Positive pressure. Where an *appliance* equipped with a mechanical forced *draft* system creates a positive pressure in the venting system, the venting system shall be designed for positive pressure applications.

G2425.7 (501.7) Connection to fireplace. Connection of *appliances* to *chimney* flues serving *fireplaces* shall be in accordance with Sections G2425.7.1 through G2425.7.3.

G2425.7.1 (501.7.1) Closure and access. A noncombustible seal shall be provided below the point of connection to prevent entry of room air into the flue. Means shall be provided for *access* to the flue for inspection and cleaning.

G2425.7.2 (501.7.2) Connection to factory-built fireplace flue. An *appliance* shall not be connected to a flue serving a *factory-built fireplace* unless the *appliance* is specifically *listed* for such installation. The connection shall be made in accordance with the *appliance* manufacturer's installation instructions.

G2425.7.3 (501.7.3) Connection to masonry fireplace flue. A connector shall extend from the *appliance* to the flue serving a *masonry fireplace* such that the *flue gases* are exhausted directly into the flue. The connector shall be accessible or removable for inspection and cleaning of both the connector and the flue. *Listed* direct connection devices shall be installed in accordance with their listing.

G2425.8 (501.8) Appliances not required to be vented. The following *appliances* shall not be required to be vented:

1. Ranges.
2. Built-in domestic cooking units *listed* and marked for optional venting.
3. Hot plates and laundry stoves.
4. *Type 1 clothes dryers* (*Type 1 clothes dryers* shall be exhausted in accordance with the requirements of Section G2439).
5. Refrigerators.
6. Counter *appliances*.
7. Room heaters *listed* for unvented use.

Where the *appliances* listed in Items 5 through 7 are installed so that the aggregate input rating exceeds 20 Btu per hour per cubic foot (207 W/m³) of volume of the room or space in which such *appliances* are installed, one or more shall be provided with venting *systems* or other *approved* means for conveying the *vent gases* to the outdoor atmosphere so that the aggregate input rating of the remaining *unvented appliances* does not exceed 20 Btu per hour per cubic foot (207 W/m³). Where the room or space in which the *appliance* is installed is directly connected to another room or space by a doorway, archway or other opening of comparable size that cannot be closed, the volume of such adjacent room or space shall be permitted to be included in the calculations.

G2425.9 (501.9) Chimney entrance. Connectors shall connect to a *masonry chimney* flue at a point not less than 12 inches (305 mm) above the lowest portion of the interior of the *chimney* flue.

G2425.10 (501.10) Connections to exhauster. *Appliance* connections to a *chimney* or vent equipped with a power exhauster shall be made on the inlet side of the exhauster. Joints on the positive pressure side of the exhauster shall be sealed to prevent flue-gas leakage as specified by the manufacturer's installation instructions for the exhauster.

G2425.11 (501.11) Masonry chimneys. *Masonry chimneys* utilized to vent *appliances* shall be located, constructed and sized as specified in the manufacturer's installation instructions for the *appliances* being vented and Section G2427.

G2425.12 (501.12) Residential and low-heat appliances flue lining systems. *Flue lining* systems for use with residential-type and low-heat *appliances* shall be limited to the following:

1. Clay *flue lining* complying with the requirements of ASTM C315 or equivalent. Clay *flue lining* shall be installed in accordance with Chapter 10.
2. *Listed chimney* lining systems complying with UL 1777.
3. Other *approved* materials that will resist, without cracking, softening or corrosion, *flue gases* and *condensate* at temperatures up to 1,800°F (982°C).

G2425.13 (501.13) Category I appliance flue lining systems. *Flue lining* systems for use with Category I *appliances* shall be limited to the following:

1. *Flue lining* systems complying with Section G2425.12.
2. *Chimney* lining systems *listed* and *labeled* for use with gas *appliances* with *draft hoods* and other Category I gas *appliances listed* and *labeled* for use with Type B vents.

G2425.14 (501.14) Category II, III and IV appliance venting systems. The design, sizing and installation of vents for Category II, III and IV *appliances* shall be in accordance with the *appliance* manufacturer's instructions.

G2425.15 (501.15) Existing chimneys and vents. Where an *appliance* is permanently disconnected from an existing *chimney* or vent, or where an *appliance* is connected to an existing *chimney* or vent during the process of a new installation, the *chimney* or vent shall comply with Sections G2425.15.1 through G2425.15.4.

G2425.15.1 (501.15.1) Size. The *chimney* or vent shall be resized as necessary to control flue gas condensation in the interior of the *chimney* or vent and to provide the *appliance* or *appliances* served with the required *draft*. For Category I *appliances*, the resizing shall be in accordance with Section G2426.

G2425.15.2 (501.15.2) Flue passageways. The flue gas passageway shall be free of obstructions and combustible deposits and shall be cleaned if previously used for venting a solid or liquid fuel-burning *appliance* or *fireplace*. The *flue liner*, *chimney* inner wall or vent inner wall shall be continuous and shall be free of cracks, gaps, perforations, or other damage or deterioration that would allow the escape of *combustion products*, including gases, moisture and creosote.

G2425.15.3 (501.15.3) Cleanout. *Masonry chimney* flues shall be provided with a cleanout opening having a minimum height of 6 inches (152 mm). The upper edge of the opening shall be located not less than 6 inches (152 mm) below the lowest *chimney* inlet opening. The cleanout shall be provided with a tight-fitting, noncombustible cover.

G2425.15.4 (501.15.4) Clearances. *Chimneys* and vents shall have airspace *clearance* to combustibles in accordance with Chapter 10 and the *chimney* or vent manufacturer's installation instructions.

Exception: *Masonry chimneys* without the required airspace *clearances* shall be permitted to be used if lined or relined with a *chimney* lining system *listed* for use in *chimneys* with reduced *clearances* in accordance with UL 1777. The *chimney clearance* shall be not less than **p** permitted by the terms of the *chimney* liner listing and the manufacturer's instructions.

G2425.15.4.1 (501.15.4.1) Fireblocking. Noncombustible fireblocking shall be provided in accordance with Chapter 10.

SECTION G2426 (502) **VENTS**

G2426.1 (502.1) General. Vents, except as provided in Section G2427.7, shall be *listed and labeled*. Type B and BW vents shall be tested in accordance with UL 441. Type L vents shall be tested in accordance with UL 641. Vents for Category II and III *appliances* shall be tested in accordance with UL 1738. Plastic vents for Category IV *appliances* shall not be required to be *listed and labeled* where such vents are as specified by the *appliance* manufacturer and are installed in accordance with the *appliance* manufacturer's instructions.

G2426.2 (502.2) Connectors required. Connectors shall be used to connect *appliances* to the vertical *chimney* or vent, except where the *chimney* or vent is attached directly to the *appliance*. Vent *connector* size, material, construction and installation shall be in accordance with Section G2427.

G2426.3 (502.3) Vent application. The application of vents shall be in accordance with Table G2427.4.

G2426.4 (502.4) Insulation shield. Where ~~type B, BW and L~~ vents pass through insulated assemblies, an insulation shield constructed of steel having a minimum thickness of 0.0187 inch (0.4712 mm) (No. 26 gage) shall be installed to provide *clearance* between the vent and the insulation material. The *clearance* shall be **not** less than the *clearance* to combustibles specified by the vent manufacturer's installation instructions. Where vents pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the insulation materials and shall be secured in place to prevent displacement. Insulation shields provided as part of a *listed* vent system shall be installed in accordance with the manufacturer's instructions.

G2426.5 (502.5) Installation. Vent systems shall be sized, installed and terminated in accordance with the vent and *appliance* manufacturer's installation instructions and Section G2427.

G2426.6 (502.6) Support of vents. All portions of vents shall be adequately supported for the design and weight of the materials employed.

G2426.7 (502.7) Protection against physical damage. In *concealed locations*, where a vent is installed through holes or notches in studs, joists, rafters or similar members less than 1½ inches (38 mm) from the nearest edge of the member, the vent shall be protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575-inch (1.463 mm) (No. 16 gage) shall cover the area of the vent where the member is notched or bored and shall extend **not less than** 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.

G2426.7.1 (502.7.1) Door swing. Appliance and equipment vent terminals shall be located such that doors cannot swing within 12 inches (305 mm) horizontally of the vent terminal. Door stops or closures shall not be installed to obtain this clearance.

SECTION G2427 (503) **VENTING OF APPLIANCES**

G2427.1 (503.1) General. The venting of *appliances* shall be in accordance with Sections G2427.2 through G2427.16.

G2427.2 (503.2) Venting systems required. Except as permitted in Sections G2425.8, G2427.2.1 and G2427.2.2, all *appliances* shall be connected to *venting systems*.

G2427.2.1 (503.2.3) Direct-vent appliances. *Listed direct-vent appliances* shall be installed in accordance with the manufacturer's instructions. *Through-the-wall vent terminations for listed direct-vent appliances shall be in accordance with Section G2427.8.*

G2427.2.2 (503.2.4) Appliances with integral vents. *Appliances* incorporating integral venting means shall be installed in accordance with Section G2427.8.

G2427.3 (503.3) Design and construction. *Venting systems* shall be designed and constructed so as to convey all flue and *vent gases* to the outdoors.

G2427.3.1 (503.3.1) Appliance draft requirements. A *venting system* shall satisfy the *draft* requirements of the *appliance* in accordance with the manufacturer's instructions.

G2427.3.2 (503.3.2) Design and construction. Appliances required to be vented shall be connected to a **venting system** designed and installed in accordance with the provisions of Sections G2427.4 through G2427.16.

G2427.3.3 (503.3.3) Mechanical draft systems. Mechanical *draft* systems shall comply with the following:

1. Mechanical *draft* systems shall be **listed in accordance with UL 378** and shall be installed in accordance with the manufacturer's instructions for both the *appliance* and the mechanical *draft* system.
2. *Appliances* requiring venting shall be permitted to be vented by means of mechanical *draft* systems of either forced or induced *draft* design.
3. Forced *draft* systems and all portions of induced *draft* systems under positive pressure during operation shall be designed and installed so as to prevent leakage of flue or *vent gases* into a building.
4. *Vent connectors* serving *appliances* vented by natural *draft* shall not be connected into any portion of mechanical *draft* systems operating under positive pressure.
5. Where a mechanical *draft* system is employed, provisions shall be made to prevent the flow of gas to the *main burners* when the *draft* system is not performing so as to satisfy the operating requirements of the *appliance* for safe performance. □

G2427.3.4 (503.3.5) Air ducts and furnace plenums. *Venting systems* shall not extend into or pass through any fabricated air duct or *furnace plenum*.

G2427.3.5 (503.3.6) Above-ceiling air-handling spaces. Where a **venting system** passes through an above-ceiling air-handling space or other nonducted portion of an air-handling system, the **venting system** shall conform to one of the following requirements:

1. The **venting system** shall be a *listed special gas vent*; other **venting system** serving a Category III or Category IV *appliance*; or other positive pressure vent, with joints sealed in accordance with the *appliance* or vent manufacturer's instructions.
2. The **venting system** shall be installed such that fittings and joints between sections are not installed in the above-ceiling space.
3. The **venting system** shall be installed in a conduit or enclosure with sealed joints separating the interior of the conduit or enclosure from the ceiling space.

G2427.4 (503.4) Type of venting system to be used. The type of **venting system** to be used shall be in accordance with Table G2427.4.

**TABLE G2427.4 (503.4)
TYPE OF VENTING SYSTEM TO BE USED**

APPLIANCES	TYPE OF VENTING SYSTEM
Listed Category I appliances Listed appliances equipped with draft hood Appliances listed for use with Type B gas vent	Type B gas vent (Section G2427.6) Chimney (Section G2427.5) Single-wall metal pipe (Section G2427.7) Listed chimney lining system for gas venting (Section G2427.5.2) Special gas vent listed for these appliances (Section G2427.4.2)
Listed vented wall furnaces	Type B-W gas vent (Sections G2427.6, G2436)
Category II, Category III and Category IV appliances	As specified or furnished by manufacturers of listed appliances (Sections G2427.4.1, G2427.4.2)
Unlisted appliances	
Decorative appliances in vented fireplaces	Chimney (Section G2427.5)
Direct-vent appliances	Chimney
Appliances with integral vent	See Section G2427.2.1

G2427.4.1 (503.4.1) Plastic piping. Where plastic piping is used to vent an *appliance*, the *appliance* shall be *listed* for use with such venting materials and the *appliance* manufacturer's installation instructions shall identify the specific plastic piping material. The plastic pipe venting materials shall be *labeled* in accordance with the product standards specified by the *appliance* manufacturer or shall be *listed* in accordance with UL 1738.

G2427.4.1.1 (503.4.1.1) Plastic vent joints. Plastic *pipe* and fittings used to vent *appliances* shall be installed in accordance with the *appliance* manufacturer's instructions. Plastic pipe venting materials *listed* and *labeled* in accordance with UL 1738 shall be installed in accordance with the vent manufacturer's instructions. Where a primer is required, it shall be of a contrasting color ~~on an ultraviolet primer in accordance with Section P2906.9.1.4.~~

G2427.4.2 (503.4.2) Special gas vent. Special gas *vent* shall be *listed* and *labeled* in accordance with UL 1738 and installed in accordance with the special gas *vent* manufacturer's instructions.

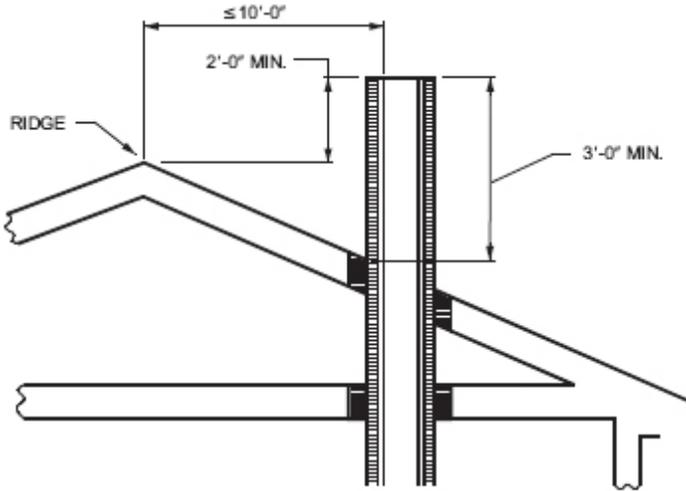
G2427.5 (503.5) Masonry, metal and factory-built chimneys. Masonry, metal and factory-built *chimneys* shall comply with Sections G2427.5.1 through G2427.5.10.

G2427.5.1 (503.5.1) Factory-built chimneys. Factory-built *chimneys* shall be *listed* in accordance with UL 103. Factory-built *chimneys* used to vent *appliances* that operate at a positive vent pressure shall be *listed* for such application.

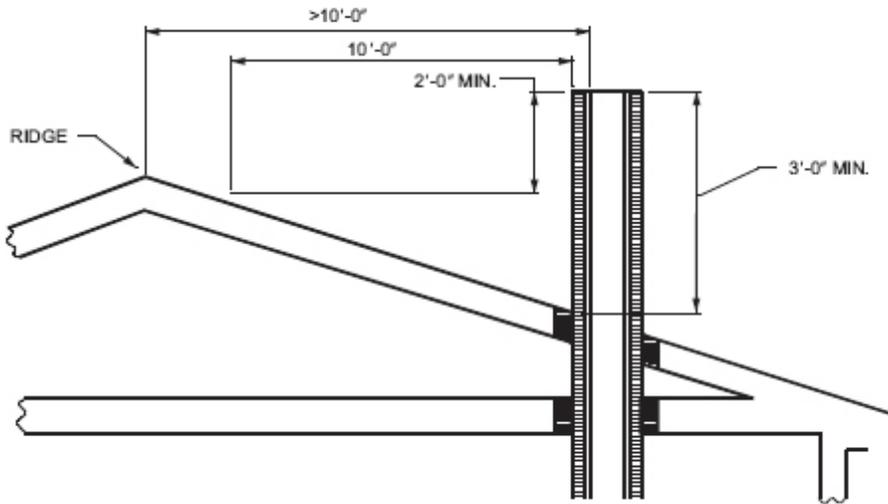
G2427.5.2 (503.5.3) Masonry chimneys. Masonry *chimneys* shall be built and installed in accordance with NFPA 211 and shall be lined with an *approved* clay *flue* lining, a *chimney* lining system *listed* and *labeled* in accordance with UL 1777 or other *approved* material that will resist corrosion, erosion, softening or cracking from vent gases at temperatures up to 1,800°F (982°C).

Exception: Masonry *chimney* flues serving *listed* gas *appliances* with *draft* hoods, Category I *appliances* and other gas *appliances* *listed* for use with Type B vents shall be permitted to be lined with a *chimney* lining system specifically *listed* for use only with such *appliances*. The liner shall be installed in accordance with the liner manufacturer's 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."

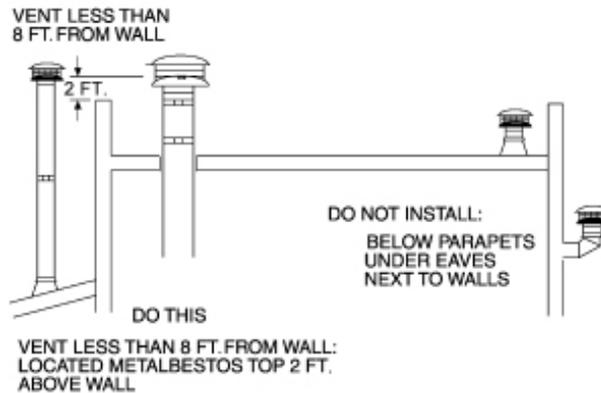
G2427.5.3 (503.5.4) Chimney termination. *Chimneys* for residential-type or low-heat *appliances* shall extend not less than 3 feet (914 mm) above the highest point where they pass through a roof of a building and not less than 2 feet (610 mm) higher than any portion of a building within a horizontal distance of 10 feet (3048 mm). *Chimneys* for medium-heat *appliances* shall extend not less than 10 feet (3048 mm) higher than any portion of any building within 25 feet (7620 mm). *Chimneys* shall extend not less than 5 feet (1524 mm) above the highest connected *appliance* *draft* hood outlet or *flue* collar. 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 instructions.



CROSS SECTION - WHEN 10 FT OR LESS FROM RIDGE



CROSS SECTION - WHEN MORE THAN 10 FT FROM RIDGE



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

FIGURE G2427.5.3
TYPICAL TERMINATION LOCATIONS FOR CHIMNEYS SERVING
RESIDENTIAL-TYPE AND LOW-HEAT APPLIANCES

G2427.5.4 (503.5.5) 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 determined in accordance with one of the following methods:

1. The provisions of Section G2428.
2. **The effective areas of the vent connector and chimney flue of a venting system serving** a single *appliance* with a *draft hood* shall be not less than the area of the *appliance flue collar* or *draft hood* outlet, nor greater than seven times the *draft hood* outlet area.
3. **The effective area of a chimney flue or a venting system serving** two *appliances* with *draft hoods*.
4. *Chimney venting systems* using mechanical *draft* shall be sized in accordance with *approved* engineering methods.
5. Other *approved* engineering methods.

G2427.5.5 (503.5.6) Inspection of chimneys. Before replacing an existing *appliance* or connecting a vent *connector* to a *chimney*, the *chimney* passageway shall be examined to ascertain that it is clear and free of obstructions and it shall be cleaned if previously used for venting solid or liquid fuel-burning *appliances* or *fireplaces*.

G2427.5.5.1 (503.5.6.1) Chimney lining. *Chimneys* shall be lined in accordance with NFPA 211. □

G2427.5.5.2 (503.5.6.2) Cleanouts. Cleanouts shall be examined **and where they do not** remain tightly closed when not in use, **they shall be repaired or replaced.**

G2427.5.5.3 (503.5.6.3) Unsafe chimneys. 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* to conform to NFPA 211 and it shall be suitable for the *appliances* to be vented.

G2427.5.6 (503.5.7) Chimneys serving appliances burning other fuels. *Chimneys* serving *appliances* burning other fuels shall comply with Sections G2427.5.6.1 through G2427.5.6.4.

G2427.5.6.1 (503.5.7.1) Solid fuel-burning appliances. An *appliance* shall not be connected to a *chimney* flue serving a separate *appliance* designed to burn solid fuel.

G2427.5.6.2 (503.5.7.2) Liquid fuel-burning appliances. Where one *chimney* flue 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 suitable 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 *appliances* are automatically controlled, they shall be equipped with *safety shutoff devices*.

G2427.5.6.3 (503.5.7.3) Combination gas- and solid fuel-burning appliances. A combination gas- and solid fuel-burning *appliance* shall be permitted to be connected to a single *chimney* flue where 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*.

G2427.5.6.4 (503.5.7.4) Combination gas- and oil fuel-burning appliances. Where a single *chimney* flue serves a *listed* combination gas- and oil fuel-burning *appliance*, **such flue shall be sized in accordance with the appliance manufacturer's instructions.**

G2427.5.7 (503.5.8) Support of chimneys. All portions of *chimneys* shall be supported for the design and weight of the materials employed. Factory-built *chimneys* shall be supported and spaced in accordance with the manufacturer's installation instructions.

G2427.5.8 (503.5.9) 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.

G2427.5.9 (503.5.10) Space surrounding lining or vent. The remaining space surrounding a *chimney* liner, gas vent, special gas vent or plastic *pipng* installed within a masonry *chimney* flue shall not be used to vent another *appliance*. The insertion of another liner or vent within the *chimney* as provided in this *code* and the liner or vent manufacturer's instructions shall not be prohibited.

The remaining space surrounding a *chimney* liner, gas vent, special gas vent or plastic *pipng* installed within a masonry, metal or factory-built *chimney* shall not be used to supply *combustion air*. Such space shall not be

prohibited from supplying *combustion air to direct-vent appliances* designed for installation in a solid fuel-burning *fireplace* and installed in accordance with the manufacturer's instructions.

G2427.5.10 (503.5.11) Insulation shield. Where a factory-built chimney passes through insulated assemblies, an insulation shield constructed of steel having a thickness of not less than 0.0187 inch (0.475 mm) (nominal 26 gage) shall be installed to provide clearance between the chimney and the insulation material. The clearance shall be not less than the clearance to combustibles specified by the chimney manufacturer's installation instructions. Where chimneys pass through attic space, the shield shall terminate not less than 2 inches (51 mm) above the installation materials and shall be secured in place to prevent displacement.

G2427.6 (503.6) Gas vents. Gas vents shall comply with Sections G2427.6.1 through G2427.6.12. (See Section G2403, **General** Definitions.)

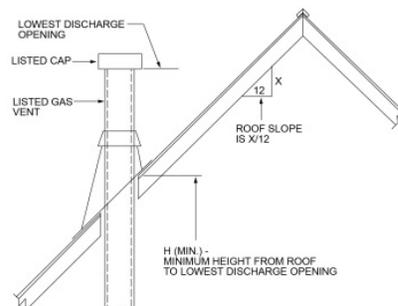
G2427.6.1 (503.6.1) Materials. Type B and BW gas vents shall be *listed* in accordance with UL 441. Vents for *listed* combination gas- and oil-burning *appliances* shall be *listed* in accordance with UL 641.

G2427.6.2 (503.6.2) Installation, general. Gas vents shall be installed in accordance with the manufacturer's instructions.

G2427.6.3 (503.6.3) Type B-W vent capacity. A Type B-W gas vent shall have a listed capacity not less than that of the *listed vented wall furnace* to which it is connected.

G2427.6.4 (503.6.4) Gas vent terminations. 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 G2427.6.4.
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 any portion of a building within 10 feet (3048 mm) horizontally.
3. As provided for direct-vent systems in Section G2427.2.1.
4. As provided for *appliances* with integral vents in Section G2427.2.2.
5. As provided for mechanical *draft* systems in Section G2427.3.3.



ROOF SLOPE	H (minimum) ft
Flat to 6/12	1.0
Over 6/12 to 7/12	1.25
Over 7/12 to 8/12	1.5
Over 8/12 to 9/12	2.0
Over 9/12 to 10/12	2.5
Over 10/12 to 11/12	3.25
Over 11/12 to 12/12	4.0
Over 12/12 to 14/12	5.0
Over 14/12 to 16/12	6.0
Over 16/12 to 18/12	7.0
Over 18/12 to 20/12	7.5
Over 20/12 to 21/12	8.0

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

FIGURE G2427.6.4 (503.6.5)
TERMINATION LOCATIONS FOR GAS VENTS WITH LISTED CAPS 12 INCHES OR LESS
IN SIZE NOT LESS THAN 8 FEET FROM A VERTICAL WALL

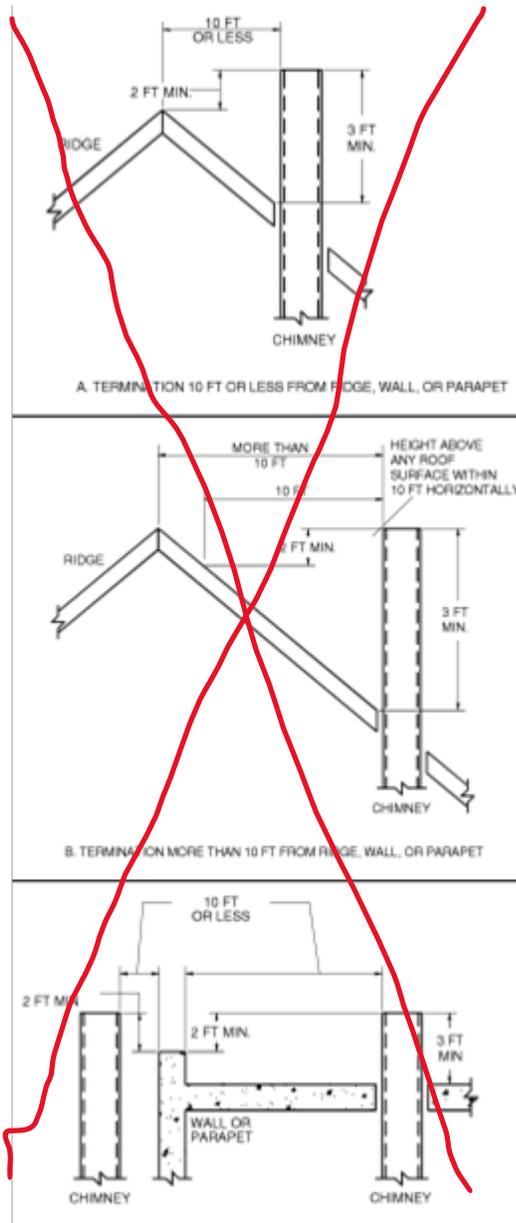


FIGURE G2427.6.3 (503.6.4)-continued
TERMINATION LOCATIONS FOR GAS VENTS WITH LISTED CAPS 12 INCHES OR LESS
IN SIZE AT LEAST 8 FEET FROM A VERTICAL WALL

G2427.6.4.1 (503.6.5.1) 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 manufacturer's instructions.

G2427.6.5 (503.6.6) Minimum height. A Type B or 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*. 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*.

G2427.6.6 (503.6.7) Roof terminations. Gas vents shall extend through the roof flashing, roof jack or roof thimble and terminate with a *listed* cap or *listed roof assembly*.

G2427.6.7 (503.6.8) Forced air inlets. Gas vents shall terminate not less than 3 feet (914 mm) above any forced air inlet located within 10 feet (3048 mm).

G2427.6.8 (503.6.9) Exterior wall penetrations. A gas *vent* extending through an exterior wall shall not terminate adjacent to the wall or below eaves or parapets, except as provided in Sections G2427.2.1 and G2427.3.3.

G2427.6.9 (503.6.10) Size of gas vents. *Venting systems* shall be sized and constructed in accordance with Sections G2427.6.9.1 through G2427.6.9.4 and the *appliance* manufacturer's installation instructions.

G2427.6.9.1 (503.6.10.1) 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 Type B gas vent, installed in a single story of a building, shall be in accordance with one of the following methods:

1. The provisions of Section G2428.
2. 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, nor greater than seven times the *draft hood* outlet area.
3. 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, nor greater than seven times the smaller *draft hood* outlet area.
4. *Approved engineering methods*.

G2427.6.9.2 (503.6.10.2) Vent offsets. Type B and L vents sized in accordance with Item 2 or 3 of Section G2427.6.9.1 shall extend in a generally vertical direction with offsets not exceeding 45 degrees (0.79 rad), except that a vent system having not more than one 60-degree (1.04 rad) *offset* shall be permitted. Any 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 be not greater than 75 percent of the vertical height of the vent.

G2427.6.9.3 (503.6.10.3) Category II, III and IV appliances. The sizing of gas vents for Category II, III and IV *appliances* shall be in accordance with the *appliance* manufacturer's instructions. The sizing of plastic pipe that is specified by the *appliance* manufacturer as a venting material for Category II, III and IV *appliances*, shall be in accordance with the *appliance* manufacturer's instructions.

G2427.6.9.4 (503.6.10.4) Mechanical draft. *Chimney venting systems* using mechanical *draft* shall be sized in accordance with *approved engineering methods*.

G2427.6.10 (503.6.12) Support of gas vents. Gas vents shall be supported and spaced in accordance with the manufacturer's installation instructions.

G2427.6.11 (503.6.13) 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 determination of where such localities exist shall be made by the *code official*. 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."

G2427.6.12 (503.6.14) Fastener penetrations. Screws, rivets and other fasteners shall not penetrate the inner wall of double-wall gas vents, except at the transition from an *appliance draft hood* outlet, a *flue collar* or a single-wall metal connector to a double-wall vent.

G2427.7 (503.7) Single-wall metal pipe. Single-wall metal *pipe* vents shall comply with Sections G2427.7.1 through G2427.7.13.

G2427.7.1 (503.7.1) Construction. Single-wall metal pipe shall be constructed of galvanized sheet steel not less than 0.0304 inch (0.7 mm) thick, or other *approved*, noncombustible, corrosion-resistant material.

G2427.7.2 (503.7.2) 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).

G2427.7.3 (503.7.3) Termination. 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*. 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) higher than any portion of a building within a horizontal distance of 10 feet (3048 mm). An *approved cap* or *roof assembly* shall be attached to the terminus of a single-wall metal pipe.

G2427.7.4 (503.7.4) Limitations of use. Single-wall metal pipe shall be used only for runs directly from the space in which the *appliance* is located through the roof or exterior wall to the outdoor atmosphere.

G2427.7.5 (503.7.5) Roof penetrations. A pipe passing through a roof shall extend without interruption through the roof flashing, roof jack or roof thimble. Where a single-wall metal pipe passes through a roof constructed of *combustible material*, a noncombustible, nonventilating thimble shall be used at the point of passage. The thimble shall extend not less than 18 inches (457 mm) above and 6 inches (152 mm) below the roof with the annular space open at the bottom and closed only at the top. The thimble shall be sized in accordance with Section G2427.7.7.

G2427.7.6 (503.7.6) Installation. Single-wall metal pipe shall not originate in any unoccupied attic or concealed space and shall not pass through any attic, inside wall, concealed space, or floor. The installation of a single-wall metal pipe through an exterior combustible wall shall comply with Section G2427.7.7.

G2427.7.7 (503.7.7) Single-wall penetrations of combustible walls. 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, the 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 open between the *draft hood* outlet and the thimble, the thimble shall be permitted to 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, all *combustible material* in the wall shall be removed a sufficient distance from the metal pipe to provide the specified *clearance* from such metal pipe to *combustible material*. Any material used to close up such opening shall be noncombustible.

G2427.7.8 (503.7.8) Clearances. Minimum *clearances* from single-wall metal pipe to *combustible material* shall be in accordance with Table G2427.10.5. The *clearance* from single-wall metal pipe to *combustible material* shall be permitted to be reduced where the *combustible material* is protected as specified for *vent connectors* in Table G2409.2.

G2427.7.9 (503.7.9) Size of single-wall metal pipe. A venting system constructed of 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 G2428.
2. For a venting system for a single *appliance* with a *draft hood*, the areas of the connector and the pipe each shall be not less than the area of the *appliance flue collar* or *draft hood* outlet, whichever is smaller. The vent area shall be **not** greater than seven times the *draft hood* outlet area.
3. **Approved** engineering methods.

G2427.7.10 (503.7.10) Pipe geometry. Any shaped single-wall metal pipe shall be permitted to be used, provided that its equivalent effective area is equal to the effective area of the round pipe for which it is substituted, and provided that the minimum internal dimension of the pipe is not less than 2 inches (51 mm).

G2427.7.11 (503.7.11) Termination capacity. The vent cap or a *roof assembly* shall have a venting capacity of not less than that of the pipe to which it is attached.

G2427.7.12 (503.7.12) Support of single-wall metal pipe. All portions of single-wall metal pipe shall be supported for the design and weight of the material employed.

G2427.7.13 (503.7.13) Marking. Single-wall metal pipe shall comply with the marking provisions of Section G2427.6.11.

G2427.8 (503.8) Venting system terminal clearances. The clearances for through-the-wall direct-vent and nondirect-vent terminals shall be in accordance with Figure G2427.8 and Table G2427.8.

Exceptions:

1. The clearances in Table G2427.8 shall not apply to the *combustion air* intake of a direct-vent *appliance*.

□

2. Exception: If manufacturer's installation instructions allow closer clearances, those instructions can be followed.

6. Externally mounted appliances. Vent systems for externally wall mounted appliances shall be located as required by the manufacturer's installation instructions.

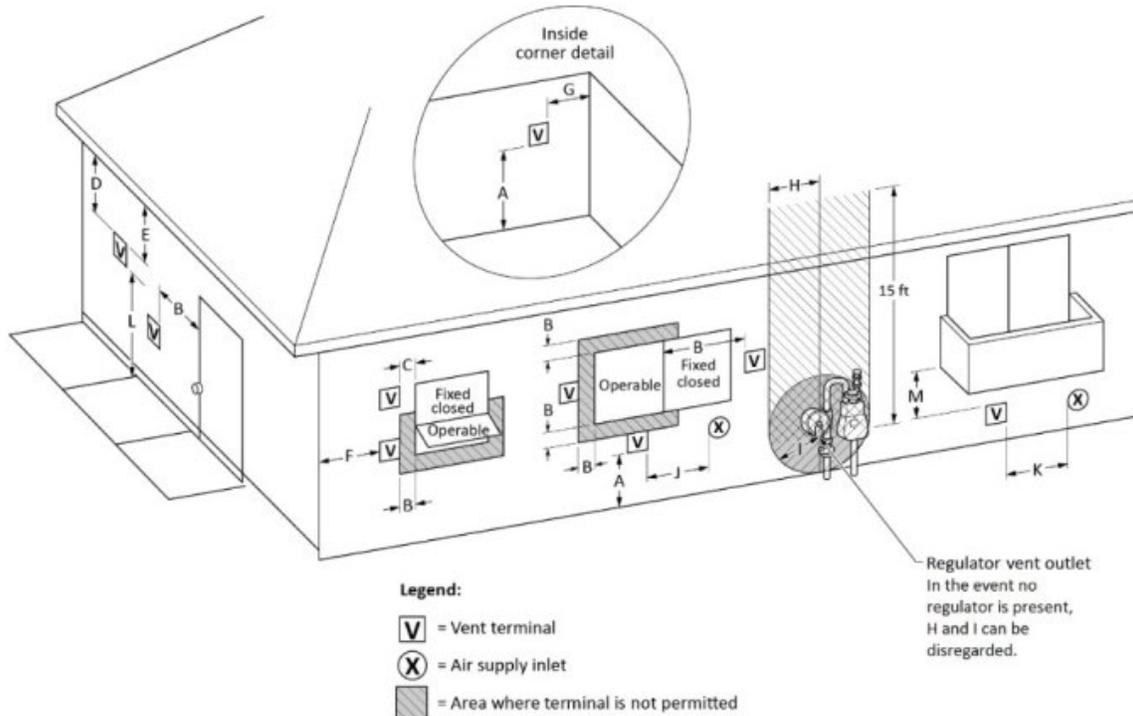


FIGURE G2427.8 (503.8)

THROUGH-THE-WALL VENT TERMINAL CLEARANCES

TABLE G2427.8 (503.8)

THROUGH-THE-WALL VENT TERMINAL CLEARANCES

FIGURE CLEARANCE	CLEARANCE LOCATION	MINIMUM CLEARANCES FOR DIRECT-VENT TERMINALS	MINIMUM CLEARANCES FOR NONDIRECT-VENT TERMINALS
A	Clearance above finished grade level, veranda, porch, deck or balcony	12 inches	
B	Clearance to window or door that is operable	6 inches: Appliances $\leq 10,000$ Btu/hr 9 inches: Appliances $> 10,000$ Btu/hr $\leq 50,000$ Btu/hr 12 inches: Appliances $> 50,000$ Btu/hr $\leq 150,000$ Btu/hr Appliances $> 150,000$ Btu/hr, in accordance with the appliance manufacturer's instructions and not less than the clearances specified for nondirect-vent terminals in Row B	4 feet below or to side of opening or 1 foot above opening
C	Clearance to nonoperable window	None unless otherwise specified by the appliance manufacturer	

D	Vertical clearance to ventilated soffit located above the terminal within a horizontal distance of 2 feet from the centerline of the terminal	None unless otherwise specified by the appliance manufacturer
E	Clearance to unventilated soffit	None unless otherwise specified by the appliance manufacturer
F	Clearance to outside corner of building	None unless otherwise specified by the appliance manufacturer
G	Clearance to inside corner of building	None unless otherwise specified by the appliance manufacturer
H	Clearance to each side of centerline extended above regulator vent outlet	3 feet up to a height of 15 feet above the regulator vent outlet
I	Clearance to service regulator vent outlet in all directions	3 feet for gas pressures up to 2 psi; 10 feet for gas pressures above 2 psi
J	Clearance to nonmechanical air supply inlet to building and the combustion air inlet to any other appliance	Same clearance as specified for Row B
K	Clearance to a mechanical air supply inlet	10 feet horizontally from inlet or 3 feet above inlet
L	Clearance above paved sidewalk or paved driveway located on public property	7 feet and shall not be located above public walkways or other areas where condensate or vapor can cause a nuisance or hazard
M	Clearance to underside of veranda, porch deck or balcony	12 inches where the area beneath the veranda, porch deck or balcony is open on not less than two sides. The vent terminal is prohibited in this location where only one side is open.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1 Btu/h = 0.293 W.

G2427.9 (503.9) Condensation drainage. Provisions shall be made to collect and dispose of *condensate* from *venting systems* serving Category II and IV *appliances* and noncategorized condensing *appliances*. *Drains for condensate* shall be installed in accordance with the *appliance* and vent manufacturer's instructions.

G2427.10 (503.10) Vent connectors for Category I appliances. *Vent connectors* for Category I *appliances* shall comply with Sections G2427.10.1 through G2427.10.14.

G2427.10.1 (503.10.1) Where required. 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*.

G2427.10.2 (503.10.2) Materials. *Vent connectors* shall be constructed in accordance with Sections G2427.10.2.1 through G2427.10.2.4.

G2427.10.2.1 (503.10.2.1) General. A *vent connector* shall be made of noncombustible corrosion-resistant material capable of withstanding the vent gas temperature produced by the *appliance* and of sufficient thickness to withstand physical damage.

G2427.10.2.2 (503.10.2.2) Vent connectors located in unconditioned areas. Where the *vent connector* used for an *appliance* having a *draft hood* or a Category I *appliance* is located in or passes through attics, crawl spaces or other unconditioned spaces, that portion of the *vent connector* shall be *listed* Type B, Type L or *listed* vent material having equivalent insulation properties.

Exception: Single-wall metal pipe located within the exterior walls of the building in areas having a local 99-percent winter design temperature of 5°F (-15°C) or higher shall be permitted to be used in unconditioned spaces other than attics and crawl spaces.

G2427.10.2.3 (503.10.2.3) Residential-type appliance connectors. Where *vent connectors* for residential-type *appliances* are not installed in attics or other unconditioned spaces, connectors for *listed appliances* having *draft hoods*, *appliances* having *draft hoods* and equipped with *listed conversion burners* and Category I *appliances* shall be one of the following:

1. Type B or L vent material.
2. Galvanized sheet steel not less than 0.018 inch (0.46 mm) thick.
3. Aluminum (1100 or 3003 alloy or equivalent) sheet not less than 0.027 inch (0.69 mm) thick.
4. Stainless steel sheet not less than 0.012 inch (0.31 mm) thick.
5. Smooth interior wall metal pipe having resistance to heat and corrosion equal to or greater than that of Item 2, 3 or 4.
6. A *listed vent connector*.

Vent connectors shall not be covered with insulation.

Exception: *Listed insulated vent connectors* shall be installed in accordance with the manufacturer's instructions.

G2427.10.2.4 (503.10.2.4) Low-heat appliance. A *vent connector* for a nonresidential, low-heat *appliance* shall be a factory-built *chimney* section or steel *pipe* having resistance to heat and corrosion equivalent to that for the appropriate galvanized pipe as specified in Table G2427.10.2.4. Factory-built *chimney* sections shall be joined together in accordance with the *chimney* manufacturer's instructions.

TABLE G2427.10.2.4 (503.10.2.4)

MINIMUM THICKNESS FOR GALVANIZED STEEL VENT CONNECTORS FOR LOW-HEAT APPLIANCES

DIAMETER OF CONNECTOR (inches)	MINIMUM THICKNESS (inch)
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: 1 inch = 25.4 mm.

G2427.10.3 (503.10.3) Size of vent connector. *Vent connectors* shall be sized in accordance with Sections G2427.10.3.1 through G2427.10.3.5.

G2427.10.3.1 (503.10.3.1) Single draft hood and fan-assisted. A *vent connector* for an *appliance* with a single *draft hood* or for a Category I fan-assisted *combustion system appliance* shall be sized and installed in accordance with Section G2428 or *approved engineering methods*.

G2427.10.3.2 (503.10.3.2) Multiple draft hood. Where a single *appliance* having more than one *draft hood* outlet or *flue collar* is installed, 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 methods*. 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 a rise of not less than 12 inches (305 mm).

G2427.10.3.3 (503.10.3.3) Multiple appliances. Where two or more *appliances* are connected to a common *vent* or *chimney*, each *vent connector* shall be sized in accordance with Section G2428 or *approved engineering methods*.

As an alternative method applicable only where all of the *appliances* are *draft hood* equipped, each *vent connector* shall have an effective area not less than the area of the *draft hood* outlet of the *appliance* to which it is connected.

G2427.10.3.4 (503.10.3.4) Common connector/manifold. 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 the required *clearance to combustible materials* and shall be sized in accordance with Section G2428 or *approved engineering methods*.

As an alternate method applicable only where there are two *draft hood*-equipped *appliances*, the effective area of the common *vent connector* or vent manifold and all junction fittings shall be not less than the area of the larger *vent connector* plus 50 percent of the area of the smaller *flue collar* outlet.

G2427.10.3.5 (503.10.3.5) 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.

G2427.10.4 (503.10.4) Two or more appliances connected to a single vent or chimney. 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*. *Vent connectors* serving Category I *appliances* shall not be connected to any portion of a *mechanical draft system* operating under positive static pressure, such as those serving Category III or IV *appliances*.

G2427.10.4.1 (503.10.4.1) Two or more openings. Where two or more openings are provided into one *chimney flue or vent*, 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.

G2427.10.5 (503.10.5) Clearance. Minimum *clearances* from *vent connectors* to *combustible material* shall be in accordance with Table G2427.10.5.

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 G2409.2.

**TABLE G2427.10.5 (503.10.5)
CLEARANCES FOR CONNECTORS^a**

APPLIANCE	MINIMUM DISTANCE FROM COMBUSTIBLE MATERIAL			
	Listed Type B gas vent material	Listed Type L vent material	Single-wall metal pipe	Factory-built chimney sections
Listed appliances with draft hoods and appliances listed for use with Type B gas vents	As listed	As listed	6 inches	As listed
Residential boilers and furnaces with listed gas conversion burner and with draft hood	6 inches	6 inches	9 inches	As listed
Residential appliances listed for use with Type L vents	Not permitted	As listed	9 inches	As listed
Listed gas-fired toilets	Not permitted	As listed	As listed	As listed
Unlisted residential appliances with draft hood	Not permitted	6 inches	9 inches	As listed
Residential and low-heat appliances other than above	Not permitted	9 inches	18 inches	As listed
Medium-heat appliances	Not permitted	Not permitted	36 inches	As listed

For SI: 1 inch = 25.4 mm.

- a. These clearances shall apply unless the manufacturer's installation instructions for a listed appliance or connector specify different clearances, in which case the listed clearances shall apply.

G2427.10.6 (503.10.6) Joints. Joints between sections of connector piping and connections to *flue collars* and *draft hood* outlets shall be fastened by one of the following methods:

1. Sheet metal screws.
2. *Vent connectors* of listed vent material assembled and connected to *flue collars* or *draft hood* outlets in accordance with the manufacturer's instructions.
3. Other *approved* means.

G2427.10.7 (503.10.7) Connector junctions. Where *vent connectors* are joined together, the connection shall be made with a tee or wye fitting.

G2427.10.8 (503.10.8) Slope. A *vent connector* shall be installed without dips or sags and shall slope upward toward the vent or *chimney* not less than $\frac{1}{4}$ inch per foot (21 mm/m).

Exception: *Vent connectors* attached to a mechanical *draft* system installed in accordance with the *appliance* and *draft* system manufacturers' instructions.

G2427.10.9 (503.10.9) Length of vent 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. 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.

G2427.10.10 (503.10.10) 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.

G2427.10.11 (503.10.11) 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 firmly 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 (see Section G2425.9).

G2427.10.12 (503.10.12) Inspection. The entire length of a *vent connector* shall be provided with *ready access* for inspection, cleaning and replacement.

G2427.10.13 (503.10.13) Fireplaces. A *vent connector* shall not be connected to a *chimney* flue serving a *fireplace* unless the *fireplace* flue opening is permanently sealed.

G2427.10.14 (503.10.14) Passage through ceilings, floors or walls. Single-wall metal pipe connectors shall not pass through any wall, floor or ceiling except as permitted by Section G2427.7.4.

G2427.11 (503.11) Vent connectors for Category II, III and IV appliances. *Vent connectors* for Category II, III and IV *appliances* shall be as specified for the *venting systems* in accordance with Section G2427.4.

G2427.12 (503.12) Draft hoods and draft controls. The installation of *draft hoods* and draft controls shall comply with Sections G2427.12.1 through G2427.12.7.

G2427.12.1 (503.12.1) Appliances requiring draft hoods. *Vented appliances* shall be installed with *draft hoods*.

Exception: Dual oven-type combination ranges; *direct-vent appliances*; fan-assisted *combustion* system *appliances*; *appliances* requiring *chimney draft* for operation; single firebox boilers equipped with *conversion burners* with inputs greater than 400,000 *Btu* per hour (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.

G2427.12.2 (503.12.2) Installation. A *draft hood* supplied with or forming a part of a *listed vented appliance* shall be installed without *alteration*, exactly as furnished and specified by the *appliance* manufacturer.

G2427.12.2.1 (503.12.2.1) Draft hood required. If a *draft hood* is not supplied by the *appliance* manufacturer where one is required, a *draft hood* shall be installed, shall be of a *listed* or *approved* type and, in the absence of other instructions, shall 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. □

G2427.12.3 (503.12.3) 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.

G2427.12.4 (503.12.4) Additional devices. *Appliances* requiring a controlled *chimney draft* shall be permitted to be equipped with a *listed* double-acting barometric-*draft regulator* installed and adjusted in accordance with the manufacturer's instructions.

G2427.12.5 (503.12.5) Location. *Draft hoods* and *barometric draft regulators* shall be installed in the same room or enclosure as the *appliance* in such a manner as to prevent any difference in pressure between the hood or *regulator* and the *combustion air* supply.

G2427.12.6 (503.12.6) Positioning. *Draft hoods* and *draft regulators* shall be installed in the position for which they were designed with reference to the horizontal and vertical planes and shall be located so that the *relief opening* is not obstructed by any part of the *appliance* or adjacent construction. The *appliance* and its *draft hood* shall be located so that the *relief opening* is accessible for checking *vent* operation.

G2427.12.7 (503.12.7) Clearance. A *draft hood* shall be located so its *relief opening* is not less than 6 inches (152 mm) from any surface except that of the *appliance* it serves and the venting system to which the *draft hood* is connected. Where a greater or lesser *clearance* is indicated on the *appliance label*, the *clearance* shall be not less than that specified on the *label*. Such *clearances* shall not be reduced.

G2427.13 (503.13) Manually operated dampers. A manually operated *damper* shall not be placed in the vent connector for any *appliance*. Fixed baffles and balancing baffles shall not be classified as manually operated *dampers*.

G2427.13.1 (503.13.1) Balancing baffles. Balancing baffles shall be *listed* in accordance with UL 378 and shall be mechanically locked in the desired position before placing the *appliance* in operation.

G2427.14 (503.14) Automatically operated vent dampers. An automatically operated vent damper shall be *listed*.

G2427.15 (503.15) 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 instructions.
2. *Approved draft regulators* and safety *controls* that are 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 instructions.
4. *Approved* economizers, heat reclaimers and recuperators installed in *venting systems* of *appliances* not required to be equipped with *draft hoods*, provided that the *appliance* manufacturer's instructions cover the installation of such a device in the venting system and performance in accordance with Sections G2427.3 and G2427.3.1 is obtained.
5. Vent dampers serving *listed appliances* installed in accordance with Sections G2428.2.1 and G2428.3.1 or *approved* engineering methods.

G2427.16 (503.16) (IFGS) Outside wall penetrations. Where vents, including those for *direct-vent appliances*, 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.

SECTION G2428 (504) SIZING OF CATEGORY I APPLIANCE VENTING SYSTEMS

G2428.1 (504.1) Definitions. The following definitions apply to the tables in this section:

APPLIANCE CATEGORIZED VENT DIAMETER/AREA. The minimum vent area/diameter permissible for Category I *appliances* to maintain a nonpositive vent static pressure when tested in accordance with nationally recognized standards.

FAN + FAN. The maximum combined *appliance* input rating of two or more Category I fan-assisted *appliances* attached to the common vent.

FAN Max. The maximum input rating of a Category I fan-assisted *appliance* attached to a vent or connector.

FAN Min. The minimum input rating of a Category I fan-assisted *appliance* attached to a vent or connector.

FAN + NAT. The maximum combined *appliance* input rating of one or more Category I fan-assisted *appliances* and one or more Category I draft hood-equipped *appliances* attached to the common vent.

FAN-ASSISTED COMBUSTION SYSTEM. An *appliance* equipped with an integral mechanical means to either draw or force products of *combustion* through the *combustion chamber* or heat exchanger.

NA. Vent configuration is not *allowed* due to potential for *condensate* formation or pressurization of the venting system, or not applicable due to physical or geometric restraints.

NAT Max. The maximum input rating of a Category I draft hood-equipped **appliance** attached to a vent or connector.

NAT + NAT. The maximum combined **appliance** input rating of two or more Category I draft hood-equipped **appliances** attached to the common vent.

G2428.2 (504.2) Application of single-appliance vent Tables G2428.2(1) and G2428.2(2). The application of Tables G2428.2(1) and G2428.2(2) shall be subject to the requirements of Sections G2428.2.1 through G2428.2.17.

G2428.2.1 (504.2.1) Vent obstructions. These venting tables shall not be used where obstructions, as described in Section G2427.15, are installed in the venting system. The installation of vents serving *listed appliances* with vent dampers shall be in accordance with the *appliance* manufacturer's instructions or in accordance with the following:

1. The maximum capacity of the vent system shall be determined using the "NAT Max" column.
2. The minimum capacity shall be determined as if 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.

G2428.2.2 (504.2.2) Minimum size. Where the vent size determined from the tables is smaller than the *appliance draft hood outlet or flue collar*, the smaller size shall be permitted to be used provided **that** all of the following requirements are met:

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* larger than 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 ($0.90 \times$ maximum table capacity).
5. The *draft hood* outlet is greater than 4 inches (102 mm) in diameter. Do not connect a 3-inch-diameter (76 mm) vent to a 4-inch-diameter (102 mm) *draft hood* outlet. This provision shall not apply to fan-assisted *appliances*.

G2428.2.3 (504.2.3) Vent offsets. Single-*appliance* venting configurations with zero (0) lateral lengths in Tables G2428.2(1) and G2428.2(2) shall not have elbows in the *venting system*. Single-*appliance* venting configurations with lateral lengths include two 90-degree (1.57 rad) elbows. For each additional elbow up to and including 45 degrees (0.79 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 rad) up to and including 90 degrees (1.57 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 all *offsets* combined shall not exceed that specified in Tables G2428.2(1) and G2428.2(2).

G2428.2.4 (504.2.4) Zero lateral. Zero (0) lateral (L) shall apply only to a straight vertical vent attached to a top outlet *draft hood* or *flue collar*.

G2428.2.5 (504.2.5) High-altitude installations. Sea-level input ratings shall be used when determining maximum capacity for high-altitude installation. Actual input, derated for altitude, shall be used for determining minimum capacity for high-altitude installation.

G2428.2.6 (504.2.6) Multiple input rate appliances. For *appliances* with more than one input rate, the minimum vent capacity (FAN Min) determined from the tables shall be less than the lowest *appliance* input rating, and the maximum vent capacity (FAN Max/NAT Max) determined from the tables shall be greater than the highest *appliance* rating input.

G2428.2.7 (504.2.7) Liner system sizing and connections. *Listed* corrugated metallic *chimney* liner systems in masonry *chimneys* shall be sized by using Table G2428.2(1) or G2428.2(2) for Type B vents with the maximum capacity reduced by 20 percent ($0.80 \times$ maximum capacity) and the minimum capacity as shown in Table G2428.2(1) or G2428.2(2). Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Section G2428.2.3. 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.

Connections between *chimney* liners and *listed* double-wall connectors shall be made with *listed* adapters designed for such purpose.

G2428.2.8 (504.2.8) Vent area and diameter. 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.

G2428.2.9 (504.2.9) Chimney and vent locations. Tables G2428.2(1) and G2428.2(2) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or *listed* chimney lining system passing through an unused *masonry chimney* flue shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Figure G2427.6.4, and where vents terminate in accordance with Section G2427.6.4, Item 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. A Type B vent shall not be considered to be exposed to the outdoors where it passes through an unventilated enclosure or chase insulated to a value of not less than R-8.

G2428.2.10 (504.2.10) Corrugated vent connector size. Corrugated *vent connectors* shall be not smaller than the *listed appliance* categorized vent diameter, *flue collar* diameter, or *draft hood* outlet diameter.

G2428.2.11 (504.2.11) Vent connector size limitation. *Vent connectors* shall not be increased in size more than two sizes greater than the *listed appliance* categorized vent diameter, *flue collar* diameter or *draft hood* outlet diameter.

G2428.2.12 (504.2.12) Component commingling. In a single run of vent or *vent connector*, different diameters and types of vent and connector components shall be permitted to be used, provided that all such sizes and types are permitted by the tables.

G2428.2.13 (504.2.13) 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 manufacturer's instructions for such *listed* accessories.

G2428.2.14 (504.2.14) Table interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between the table entries.

G2428.2.15 (504.2.15) Extrapolation prohibited. Extrapolation beyond the table entries shall not be permitted.

G2428.2.16 (504.2.16) Engineering calculations. Where a *vent height* is less than 6 feet (1829 mm) or greater than shown in the tables, an engineering *method* shall be used to calculate the *vent capacity*.

G2428.2.17 (504.2.17) Height entries. Where the actual height of a vent falls between entries in the height column of the applicable table in Tables G2428.2(1) and G2428.2(2), either interpolation shall be used or the lower *appliance* input rating shown in the table entries shall be used for FAN Max and NAT Max column values and the higher *appliance* input rating shall be used for the FAN Min column values.

G2428.3 (504.3) Application of multiple appliance vent Tables G2428.3(1) through G2428.3(4). The application of Tables G2428.3(1) through G2428.3(4) shall be subject to the requirements of Sections G2428.3.1 through G2428.3.24.

G2428.3.1 (504.3.1) Vent obstructions. These venting tables shall not be used where obstructions, as described in Section G2427.15, are installed in the venting system. The installation of vents serving *listed appliances* with vent dampers shall be in accordance with the *appliance* manufacturer's instructions or in accordance with the following:

1. The maximum capacity of the *vent connector* shall be determined using the NAT Max column.
2. The maximum capacity of the vertical vent or *chimney* shall be determined using the FAN + NAT column where the second *appliance* is a fan-assisted *appliance*, or the NAT + NAT column where the second *appliance* is equipped with a *draft hood*.
3. The minimum capacity shall be determined as if the *appliance* were a fan-assisted *appliance*.
 - 3.1. The minimum capacity of the *vent connector* shall be determined using the FAN Min column.
 - 3.2. 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.

G2428.3.2 (504.3.2) Connector length limit. The *vent connector* shall be routed to the vent utilizing the shortest possible route. Except as provided in Section G2428.3.3, the maximum *vent connector* horizontal length shall be 1½ feet for each inch (18 mm per mm) of connector diameter as shown in Table G2428.3.2.

**TABLE G2428.3.2 (504.3.2)
MAXIMUM VENT CONNECTOR LENGTH**

CONNECTOR DIAMETER (inches)	CONNECTOR MAXIMUM HORIZONTAL LENGTH (feet)
3	4½
4	6
5	7½
6	9
7	10½
8	12
9	13½

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

G2428.3.3 (504.3.3) Connectors with longer lengths. Connectors with longer horizontal lengths than those listed in Section G2428.3.2 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 allowed by Section G2428.3.2. For example, the maximum length listed in Table G2428.3.2 for a 4-inch (102 mm) connector is 6 feet (1829 mm). With a connector length greater than 6 feet (1829 mm) but not exceeding 12 feet (3658 mm), the maximum capacity must be reduced by 10 percent ($0.90 \times$ maximum vent *connector* capacity). With a connector length greater than 12 feet (3658 mm), but not exceeding 18 feet (5486 mm), the maximum capacity must be reduced by 20 percent ($0.80 \times$ 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 G2428.2(1) shall be used. For single-wall connectors, Table G2428.2(2) shall be used. The height (H) and lateral (L) shall be measured according to the procedures for a single-*appliance* vent, as if the other *appliances* were not present.

G2428.3.4 (504.3.4) Vent connector manifold. 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 ($0.90 \times$ maximum common vent capacity) to the common vent capacity part of the common vent tables. The length of the common *vent connector* manifold (L_m) shall not exceed 1½ feet for each inch (18 mm per mm) of common *vent connector* manifold diameter (D).

G2428.3.5 (504.3.5) Common vertical vent offset. Where the common vertical vent is *offset*, the maximum capacity of the common vent shall be reduced in accordance with Section G2428.3.6. The horizontal length of the common vent *offset* (L_o) shall not exceed 1½ feet for each inch (18 mm per mm) of common vent diameter (D). Where multiple *offsets* occur in a common vent, the total horizontal length of all *offsets* combined shall not exceed 1½ feet for each inch (18 mm per mm) of the common vent diameter (D).

G2428.3.6 (504.3.6) Elbows in vents. For each elbow up to and including 45 degrees (0.79 rad) in the common vent, the maximum common vent capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 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.

G2428.3.7 (504.3.7) Elbows in connectors. The *vent connector* capacities listed in the common vent sizing tables include allowance for two 90-degree (1.57 rad) elbows. For each additional elbow up to and including 45 degrees (0.79 rad), the maximum *vent connector* capacity listed in the venting tables shall be reduced by 5 percent. For each elbow greater than 45 degrees (0.79 rad) up to and including 90 degrees (1.57 rad), the maximum *vent connector* capacity listed in the venting tables shall be reduced by 10 percent.

G2428.3.8 (504.3.8) Common vent minimum size. The cross-sectional area of the common vent shall be equal to or greater than the cross-sectional area of the largest connector.

G2428.3.9 (504.3.9) Common vent fittings. At the point where tee or wye fittings connect to a common 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 vent connectors*.

G2428.3.9.1 (504.3.9.1) Tee and wye fittings. Tee and wye fittings connected to a common gas vent shall be considered to be part of the common gas vent and shall be constructed of materials consistent with that of the common gas vent.

G2428.3.10 (504.3.10) High-altitude installations. Sea-level input ratings shall be used when determining maximum capacity for high-altitude installation. Actual input, derated for altitude, shall be used for determining minimum capacity for high-altitude installation.

G2428.3.11 (504.3.11) Connector rise measurement. 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.

G2428.3.12 (504.3.12) Vent height measurement. For multiple *appliances* all located on one floor, available total height (*H*) shall be measured from the highest *draft hood* outlet or *flue collar* up to the level of the outlet of the common vent.

G2428.3.13 (504.3.13) Vertical vent maximum size. 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*.

G2428.3.14 (504.3.14) Multiple input rate appliances. The minimum *vent connector* capacity (FAN Min) for *appliances* with more than one input rate shall be determined from the tables and shall be less than the lowest *appliance* input rating. The maximum *vent connector* capacity (FAN Max or NAT Max) for *appliances* with more than one input rate shall be determined from the tables and shall be greater than the highest *appliance* input rating.

G2428.3.15 (504.3.15) Liner system sizing and connections. *Listed*, corrugated metallic *chimney* liner systems in masonry *chimneys* shall be sized by using Table G2428.3(1) or G2428.3(1) for Type B vents, with the maximum capacity reduced by 20 percent ($0.80 \times$ maximum capacity) and the minimum capacity as shown in Table G2428.3(1) or G2428.3(1). Corrugated metallic liner systems installed with bends or offsets shall have their maximum capacity further reduced in accordance with Sections G2428.3.5 and G2428.3.6. The 20-percent reduction for corrugated metallic *chimney* liner systems includes an allowance for one long-radius 90-degree (1.57 rad) turn at the bottom of the liner. Where double-wall connectors are required, tee and wye fittings used to connect to the common vent *chimney* liner shall be *listed* double-wall fittings. Connections between *chimney* liners and *listed* double-wall fittings shall be made with *listed* adapter fittings designed for such purpose.

G2428.3.16 (504.3.16) Chimney and vent location. Tables G2428.3(1), G2428.3(2), G2428.3(3) and G2428.3(4) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or *listed* chimney lining system passing through an unused *masonry chimney* flue shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Figure G2427.6.4 and where vents terminate in accordance with Section G2427.6.4, Item 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. A Type B vent shall not be considered to be exposed to the outdoors where it passes through an unventilated enclosure or chase insulated to a value of not less than R-8.

G2428.3.17 (504.3.17) Connector maximum and minimum size. *Vent connectors* shall not be increased in size more than two sizes greater than the *listed appliance* categorized vent diameter, *flue collar* diameter or *draft hood* outlet diameter. *Vent connectors* for *draft hood*-equipped *appliances* shall not be smaller than the *draft hood* outlet diameter. Where a *vent connector* size(s) determined from the tables for a fan-assisted *appliance(s)* is smaller than the *flue collar* diameter, the use of the smaller size(s) shall be permitted provided that the installation complies with all of the following conditions:

1. *Vent connectors* for fan-assisted *appliance flue collars* 12 inches (305 mm) in diameter or smaller are not reduced by more than one table size [for example, 12 inches to 10 inches (305 mm to 254 mm) is a one-size reduction] and those larger than 12 inches (305 mm) in diameter are not reduced more than two table sizes [for example, 24 inches to 20 inches (610 mm to 508 mm) is a two-size reduction].
2. The fan-assisted *appliance(s)* is common vented with a *draft hood*-equipped *appliance(s)*.
3. The *vent connector* has a smooth interior wall.

G2428.3.18 (504.3.22) Component commingling. Combinations of pipe sizes, and combinations of single-wall and double-wall metal pipe shall be allowed within any connector run(s) or within the common vent, provided that all of the appropriate tables permit all of the desired sizes and types of pipe, as if they were used for the entire length of the subject connector or vent. Where single-wall and Type B double-wall metal pipes are used for *vent connectors* within the same venting system, the common vent must be sized using Table G2428.3(2) or G2428.3(4), as appropriate.

G2428.3.19 (504.3.23) 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 manufacturer's instructions for such *listed* accessories.

G2428.3.20 (504.3.24) Multiple sizes permitted. Where a table permits more than one diameter of pipe to be used for a connector or vent, all of the permitted sizes shall be permitted to be used.

G2428.3.21 (504.3.25) Table interpolation. Interpolation shall be permitted in calculating capacities for vent dimensions that fall between table entries.

G2428.3.22 (504.3.26) Extrapolation prohibited. Extrapolation beyond the table entries shall not be permitted.

G2428.3.23 (504.3.27) Engineering calculations. For vent heights less than 6 feet (1829 mm) and greater than shown in the tables, engineering methods shall be used to calculate vent capacities.

G2428.3.24 (504.3.28) Height entries. Where the actual height of a vent falls between entries in the height column of the applicable table in Tables G2428.3(1) through G2428.3(4), either interpolation shall be used or the lower *appliance* input rating shown in the table shall be used for FAN Max and NAT Max column values and the higher *appliance* input rating shall be used for the FAN Min column values.

SECTION G2429 (505) DIRECT-VENT, INTEGRAL VENT, MECHANICAL VENT AND VENTILATION/EXHAUST HOOD VENTING

G2429.1 (505.1) General. The installation of direct-vent and integral vent *appliances* shall be in accordance with Section G2427. Mechanical *venting systems* shall be designed and installed in accordance with Section G2427.

SECTION G2430 (506) FACTORY-BUILT CHIMNEYS

G2430.1 (506.1) Listing. Factory-built *chimneys* for building heating *appliances* producing *flue gases* having a temperature not greater than 1,000°F (538°C), measured at the entrance to the *chimney*, shall be *listed* and *labeled* in accordance with UL 103 and shall be installed and terminated in accordance with the manufacturer's instructions.

G2430.2 (506.2) Support. Where factory-built *chimneys* are supported by structural members, such as joists and rafters, such members shall be designed to support the additional load.

SECTION G2431 (601) GENERAL

G2431.1 (601.1) Scope. Sections G2432 through G2453 shall govern the approval, design, installation, construction, maintenance, *alteration* and *repair* of the *appliances* and *equipment* specifically identified herein.

SECTION G2432 (602)
**DECORATIVE APPLIANCES FOR
INSTALLATION IN FIREPLACES**

G2432.1 (602.1) General. Decorative *appliances* for installation in *approved* solid fuel-burning *fireplaces* shall be *listed* in accordance with ANSI Z21.60/CSA 6.26 and shall be installed in accordance with the manufacturer's instructions. Manually lighted natural gas decorative *appliances* shall be *listed* in accordance with ANSI Z21.84.

G2432.2 (602.2) Flame safeguard device. Decorative *appliances* for installation in *approved* solid fuel-burning *fireplaces*, with the exception of those *listed* in accordance with ANSI Z21.84, shall utilize a direct ignition device, an ignitor or a *pilot* flame to ignite the fuel at the *main burner*, and shall be equipped with a *flame safeguard* device. The *flame safeguard* device shall automatically shut off the fuel supply to a *main burner* or group of *burners* when the means of ignition of such *burners* becomes inoperative.

G2432.3 (602.3) Prohibited installations. Decorative *appliances* for installation in *fireplaces* shall not be installed where prohibited by Section G2406.2.

SECTION G2433 (603)
LOG LIGHTERS

G2433.1 (603.1) General. Log lighters shall be *listed* in accordance with CSA 8 and shall be installed in accordance with the manufacturer's instructions.

SECTION G2434 (604)
**VENTED GAS FIREPLACES
(DECORATIVE APPLIANCES)**

G2434.1 (604.1) General. Vented gas *fireplaces* shall be *listed* in accordance with ANSI Z21.50/CSA 2.22, shall be installed in accordance with the manufacturer's instructions and shall be designed and equipped as specified in Section G2432.2.

G2434.2 (604.2) Access. Panels, grilles and access doors that are required to be removed for normal servicing operations shall not be attached to the building.

SECTION G2435 (605)
VENTED GAS FIREPLACE HEATERS

G2435.1 (605.1) General. Vented gas *fireplace* heaters shall be installed in accordance with the manufacturer's instructions, shall be *listed* in accordance with Z21.88/CSA 2.33 and shall be designed and equipped as specified in Section G2432.2.

SECTION G2436 (608)
VENTED WALL FURNACES

G2436.1 (608.1) General. Vented wall *furnaces* shall be *listed* in accordance with ANSI Z21.86/CSA 2.32 and shall be installed in accordance with the manufacturer's instructions.

G2436.2 (608.2) Venting. Vented wall *furnaces* shall be vented in accordance with Section G2427.

G2436.3 (608.3) Location. Vented wall *furnaces* shall be located so as not to cause a fire hazard to walls, floors, combustible furnishings or doors. Vented wall *furnaces* installed between bathrooms and adjoining rooms shall not circulate air from bathrooms to other parts of the building.

G2436.4 (608.4) Door swing. Vented wall *furnaces* shall be located so that a door cannot swing within 12 inches (305 mm) of an air inlet or air outlet of such *furnace* measured at right angles to the opening. Doorstops or door closers shall not be installed to obtain this *clearance*.

G2436.5 (608.5) Ducts prohibited. Ducts shall not be attached to wall *furnaces*. Casing extension boots shall not be installed unless *listed* as part of the *appliance*.

G2436.6 (608.6) Access. *Vented wall furnaces* shall be provided with access for cleaning of heating surfaces, removal of *burners*, replacement of sections, motors, *controls*, filters and other working parts, and for adjustments and lubrication of parts requiring such attention. Panels, grilles and access doors that are required to be removed for normal servicing operations shall not be attached to the building construction.

SECTION G2437 (609) FLOOR FURNACES

G2437.1 (609.1) General. *Floor furnaces* shall be *listed* in accordance with ANSI Z21.86/CSA 2.32 and shall be installed in accordance with the manufacturer's instructions.

G2437.2 (609.2) Placement. The following provisions apply to *floor furnaces*:

1. Floors. *Floor furnaces* shall not be installed in the floor of any doorway, stairway landing, aisle or passageway of any enclosure, public or private, or in an exitway from any such room or space.
2. Walls and corners. The register of a *floor furnace* with a horizontal warm air outlet shall not be placed closer than 6 inches (152 mm) to 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 permitted to be placed not closer than 6 inches (152 mm) to a wall. Wall-register models shall not be placed closer than 6 inches (152 mm) to a corner.
3. Draperies. The *furnace* shall be placed so that a door, drapery, or similar object cannot be nearer than 12 inches (305 mm) to any portion of the register of the *furnace*.
4. Floor construction. *Floor furnaces* shall not be installed in concrete floor construction built on grade.
5. *Thermostat*. The controlling *thermostat* for a *floor furnace* shall be located within the same room or space as the *floor furnace* or shall be located in an adjacent room or space that is permanently open to the room or space containing the *floor furnace*.

G2437.3 (609.3) Bracing. The floor around the *furnace* shall be braced and headed with a support framework designed in accordance with Chapter 5.

G2437.4 (609.4) Clearance. The lowest portion of the *floor furnace* shall have not less than a 6-inch (152 mm) *clearance* from the grade level; except where the lower 6-inch (152 mm) portion of the *floor furnace* is sealed by the manufacturer to prevent entrance of water, the minimum *clearance* shall be *not less* than 2 inches (51 mm). Where such *clearances* cannot be provided, the ground below and to the sides shall be excavated to form a pit under the *furnace* so that the required *clearance* is provided beneath the lowest portion of the *furnace*. A 12-inch (305 mm) minimum *clearance* shall be provided on all sides except the *control* side, which shall have an 18-inch (457 mm) minimum *clearance*.

G2437.5 (609.5) First-floor installation. Where the basement story level below the floor in which a *floor furnace* is installed is utilized as *habitable space*, such *floor furnaces* shall be enclosed as specified in Section G2437.6 and shall project into a nonhabitable space.

G2437.6 (609.6) Upper-floor installations. *Floor furnaces* installed in upper stories of buildings shall project below into nonhabitable space and shall be separated from the nonhabitable space by an enclosure constructed of *noncombustible materials*. The *floor furnace* shall be provided with *access*, *clearance* to all sides and bottom of not less than 6 inches (152 mm) and *combustion air* in accordance with Section G2407.

SECTION G2438 (613) CLOTHES DRYERS

G2438.1 (613.1) General. *Clothes dryers* shall be *listed* in accordance with ANSI Z21.5.1/CSA 7.1 and shall be installed in accordance with the manufacturer's instructions.

SECTION G2439 (614) CLOTHES DRYER EXHAUST

G2439.1 (614.1) Installation. *Clothes dryers* shall be exhausted in accordance with the manufacturer's instructions. Dryer exhaust systems shall be independent of all other systems and shall convey the moisture and any products of *combustion* to the outside of the building.

G2439.2 (614.2) Duct penetrations. Ducts that exhaust *clothes dryers* shall not penetrate or be located within any fireblocking, draftstopping or any wall, floor/ceiling or other assembly required by this *code* to be fire-resistance rated, unless such duct is constructed of galvanized steel or aluminum of the thickness specified in the mechanical provisions of this *code* and the fire-resistance rating is maintained in accordance with this *code*. Fire dampers shall not be installed in *clothes dryer* exhaust duct systems.

G2439.3 (614.4) Exhaust installation. Exhaust ducts for *clothes dryers* shall terminate on the outside of the building and shall be equipped with a backdraft *damper*. Screens shall not be installed at the duct or weathercap termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct the flow. *Clothes dryer* exhaust ducts shall not be connected to a *vent connector*, vent or *chimney*. *Clothes dryer* exhaust ducts shall not extend into or through ducts or plenums. Clothes dryer exhaust ducts shall be sealed in accordance with Section M1601.4.1.

G2439.3.1 Termination location. Exhaust duct terminations shall be in accordance with the dryer manufacturer's installation instructions. Where the manufacturer's instructions do not specify a termination location, the exhaust duct shall terminate not less than 3 feet (914 mm) in any direction from openings into buildings including openings in ventilated soffits. The exhaust duct terminations shall not discharge onto walkways, balconies, decks, breezeways, covered walkways and similar horizontal projections. Exhaust ducts shall terminate not less than 12 inches (305 mm) above finished grade.

Exception: Where the duct termination is less than 12 inches (305 mm) above finished grade, an areaway shall be provided with a cross-sectional area not less than 200 square inches (1290 cm²). The bottom of the duct termination shall be no less than 12 inches (305 mm) above the areaway bottom.

G2439.3.12 (614.4.1) Exhaust termination outlet and passageway. The passageway of dryer exhaust duct terminals shall be undiminished in size and shall provide an open area of not less than 12.5 square inches (8065 mm²).

G2439.4 (614.5) Dryer exhaust duct power ventilators. Domestic dryer exhaust duct power ventilators shall be *listed* and *labeled* to UL 705 for use in dryer exhaust duct systems. The dryer exhaust duct power ventilator shall be installed in accordance with the manufacturer's instructions.

G2439.5 (614.6) Booster fans prohibited. Domestic booster fans shall not be installed in dryer exhaust systems.

G2439.56 (614.7) Makeup air. Installations exhausting more than 200 cfm (0.09 m³/s) shall be provided with *makeup air*.

G2439.5.1 (614.7.1) Closet installation. Where a closet an enclosed space is less than 70 square feet and is designed for the installation of a *clothes dryer*, an opening having an area of not less than 100 square inches (645 mm²) for *makeup air* shall be provided in the closet enclosure, or *makeup air* shall be provided by other *approved means*.

G2439.67 (614.8) Protection required. Protective shield plates shall be placed where nails or screws from finish or other work are likely to penetrate the *clothes dryer* exhaust duct. Shield plates shall be placed on the finished face of all framing members where there is less than 1¹/₄ inches (32 mm) between the duct and the finished face of the framing member. Protective shield plates shall be constructed of steel, shall have a minimum thickness of 0.062 inch (1.6 mm) and shall extend not less than 2 inches (51 mm) above sole plates and below top plates.

G2439.78 (614.9) Domestic clothes dryer exhaust ducts. Exhaust ducts for domestic *clothes dryers* shall conform to the requirements of Sections G2439.78.1 through G2439.78.6.

G2439.78.1 (614.9.1) Material and size. Exhaust ducts shall have a smooth interior finish and shall be constructed of metal not less than 0.0160.0157 inch (0.4 mm) in thickness (28 ga galv. 26 ga Al). With the exception of the transition duct, flexible ducts are prohibited. The exhaust duct size shall be 4 inches (102 mm) nominal in diameter.

G2439.78.2 (614.9.2) Duct installation. Exhaust ducts shall be supported at 4-foot (1219 mm) intervals and secured in place. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow. Ducts shall not be joined with screws or similar fasteners that protrude more than 1/8 inch (3.2 mm) into the inside of the duct. Ducts shall not be joined with screws or similar fasteners that protrude into the inside of the duct. Ducts

shall be sealed in accordance with Section M1601.4.1. Ducts shall be mechanically fastened by one of the following methods.

- a. Nonmetallic mechanical fasteners (tie-straps) shall be *listed* to UL 181B.
- b. Metal band duct clamps are not required to be *listed*.

Where dryer exhaust ducts are enclosed in wall or ceiling cavities, such cavities shall allow the installation of the duct without deformation.

G2439.78.3 (614.9.3) Transition ducts. Transition ducts used to connect the dryer to the exhaust *duct system* shall be a single length that is *listed* and *labeled* in accordance with UL 2158A. Transition ducts shall be not more than 8 feet (2438 mm) in length and shall not be concealed within construction, and must remain entirely within the room where the *appliance* is located.

G2439.78.4 (614.9.4) Duct length. The maximum allowable exhaust duct length shall be determined by one of the methods specified in Sections G2439.78.4.1 through G2439.78.4.3.

G2439.78.4.1 (614.9.4.1) Specified length. The maximum length of the exhaust duct shall be 35 feet (10 668 mm) from the connection to the transition duct from the dryer to the outlet terminal. Where fittings are used, the maximum length of the exhaust duct shall be reduced in accordance with Table G2439.78.4.1.

TABLE G2439.78.4.1 (TABLE 614.9.4.1)
DRYER EXHAUST DUCT FITTING EQUIVALENT LENGTH

DRYER EXHAUST DUCT FITTING TYPE	EQUIVALENT LENGTH
4-inch radius mitered 45-degree elbow	2 feet 6 inches
4-inch radius mitered 90-degree elbow	5 feet
6-inch radius smooth 45-degree elbow	1 foot
6-inch radius smooth 90-degree elbow	1 foot 9 inches
8-inch radius smooth 45-degree elbow	1 foot
8-inch radius smooth 90-degree elbow	1 foot 7 inches
10-inch radius smooth 45-degree elbow	9 inches
10-inch radius smooth 90-degree elbow	1 foot 6 inches

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

G2439.78.4.2 (614.9.4.2) Manufacturer's instructions. The maximum length of the exhaust duct shall be determined by the dryer manufacturer's installation instructions. The *code official* shall be provided with a copy of the installation instructions for the make and model of the dryer. Where the exhaust duct is to be concealed, the installation instructions shall be provided to the *code official* prior to the concealment inspection. In the absence of fitting equivalent length calculations from the clothes dryer manufacturer, Table G2439.78.4.1 shall be utilized.

G2439.78.4.3 (614.9.4.3) Dryer exhaust duct power ventilator length. The maximum length of the exhaust duct shall be determined by the dryer exhaust duct power ventilator manufacturer's installation instructions.

G2439.78.5 (614.9.5) Length identification. Where the exhaust duct equivalent length exceeds 35 feet (10 668 mm), the equivalent length of the exhaust duct shall be identified on a permanent *label* or tag. The *label* or tag shall be located within 6 feet (1829 mm) of the exhaust duct connection

1. Labels shall be permanently stenciled, laminated, or commercially available plastic or metal tags.
2. Labels shall state, at a minimum (fill in the blank):

Caution: Equivalent length of _____ feet including _____ 45 deg. elbows and _____ 90 deg. elbows. Any installed dryer must be equipped with an exhaust system that meets or exceeds this equivalent length requirement.

3. Labels can be attached to wall or vent receptor.

G2439.78.6 (614.9.6) Exhaust duct required. Where space for a *clothes dryer* is provided, an exhaust *duct system* shall be installed.

Where the *clothes dryer* is not installed at the time of occupancy, the exhaust duct shall be capped at the location of the future dryer.

Exception: Where a *listed* condensing *clothes dryer* is installed prior to occupancy of the structure.

G2439.78.7 Exhaust duct termination. Exhaust ducts shall terminate not less than 12 inches (305 mm) above finished grade.

Exception: Where the duct termination is less than 12 inches (305 mm) above finished grade, an areaway shall be provided with a cross sectional area not less than 200 square inches (1290 cm²). The bottom of the duct termination shall be no less than 12 inches (305 mm) above the areaway bottom.

SECTION G2440 (615) SAUNA HEATERS

G2440.1 (615.1) General. Sauna heaters shall be installed in accordance with the manufacturer's instructions.

G2440.2 (615.2) Location and protection. Sauna heaters shall be located so as to minimize the possibility of accidental contact by a person in the room.

G2440.2.1 (615.2.1) Guards. Sauna heaters shall be protected from accidental contact by an *approved* guard or barrier of material having a low coefficient of thermal conductivity. The guard shall not substantially affect the transfer of heat from the heater to the room.

G2440.3 (615.3) Access. Panels, grilles and access doors that are required to be removed for normal servicing operations, shall not be attached to the building.

G2440.4 (615.4) Combustion and dilution air intakes. Sauna heaters of other than the direct-vent type shall be installed with the *draft hood* and *combustion air* intake located outside the sauna room. Where the *combustion air* inlet and the *draft hood* are in a dressing room adjacent to the sauna room, there shall be provisions to prevent physically blocking the *combustion air* inlet and the *draft hood* inlet, and to prevent physical contact with the *draft hood* and vent assembly, or warning notices shall be posted to avoid such contact. Any warning notice shall be easily readable, shall contrast with its background and the wording shall be in letters not less than 1/4 inch (6.4 mm) high.

G2440.5 (615.5) Combustion and ventilation air. *Combustion air* shall not be taken from inside the sauna room. *Combustion* and ventilation air for a sauna heater not of the direct-vent type shall be provided to the area in which the *combustion air* inlet and *draft hood* are located in accordance with Section G2407.

G2440.6 (615.6) Heat and time controls. Sauna heaters shall be equipped with a *thermostat* that will limit room temperature to 194°F (90°C). If the *thermostat* is not an integral part of the sauna heater, the heat-sensing element shall be located within 6 inches (152 mm) of the ceiling. If the heat-sensing element is a capillary tube and bulb, the assembly shall be attached to the wall or other support, and shall be protected against physical damage.

G2440.6.1 (615.6.1) Timers. A timer, if provided to *control main burner* operation, shall have a maximum operating time of 1 hour. The *control* for the timer shall be located outside the sauna room.

G2440.7 (615.7) Sauna room. A ventilation opening into the sauna room shall be provided. The opening shall be not less than 4 inches by 8 inches (102 mm by 203 mm) located near the top of the door into the sauna room. A ventilation opening into the sauna room as required by the manufacturer's installation instructions.

SECTION G2441 (617) POOL AND SPA HEATERS

G2441.1 (617.1) General. Pool and spa heaters shall be *listed* in accordance with ANSI Z21.56/CSA 4.7 and shall be installed in accordance with the manufacturer's instructions.

SECTION G2442 (618)
FORCED-AIR WARM-AIR FURNACES

G2442.1 (618.1) General. Forced-air warm-air *furnaces* shall be *listed* in accordance with ANSI Z21.47/CSA 2.3 or UL 795 and shall be installed in accordance with the manufacturer's instructions.

G2442.2 Forced-air furnaces. The minimum unobstructed total area of outdoor and return air ducts or openings to a forced-air warm-air furnace shall be not less than 2 square inches for each 1,000 Btu/h (4402 mm²/W) output rating capacity of the furnace and not less than that specified in the furnace manufacturer's installation instructions. The minimum unobstructed total area of supply ducts from a forced-air warm-air furnace shall be not less than 2 square inches for each 1,000 Btu/h (4402 mm²/W) output rating capacity of the furnace and not less than that specified in the furnace manufacturer's installation instructions.

With the addition of a cooling coil, the sizing criteria shall be based on 6 square inches (3870 mm²) for each 1,000 Btu/h (13,206 mm²/W) output.

Exception: The total area of supply air ducts and outdoor and return air ducts shall not be required to be larger than the minimum size required by the furnace manufacturer's installation instructions.

G2442.32 (618.2) Dampers. Volume dampers shall not be placed in the air inlet to a *furnace* in a manner that will reduce the required air to the *furnace*.

G2442.43 (618.3) Prohibited sources. Outdoor or return air for forced-air heating and cooling systems shall not be taken from the following locations:

1. Closer than 10 feet (3048 mm) from an *appliance* vent outlet, a vent opening from 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. Where there is the presence of objectionable odors, fumes or flammable vapors; or where located less than 10 feet (3048 mm) above the surface of any abutting *public way* or driveway; or where located at grade level by a sidewalk, street, alley or driveway.
3. A hazardous or insanitary location or a refrigeration machinery room as defined in the *International Mechanical Code*.
4. A room or space, the volume of which is less than 25 percent of the entire volume served by such system. Where connected by a permanent opening having an area sized in accordance with *this code*, adjoining rooms or spaces shall be considered *to be* a single room or space for the purpose of determining the volume of such rooms or spaces.

Exception: The minimum volume requirement shall not apply where the amount of return air taken from a room or space is less than or equal to the amount of supply air delivered to such room or space.

5. A room or space containing an *appliance* where such a room or space serves as the sole source of return air.

Exceptions: This shall not apply where:

1. The *appliance* is a direct-vent *appliance* or an *appliance* not requiring a vent in accordance with Section G2425.8.
2. The room or space complies with the following requirements:
 - 2.1. The return air shall be taken from a room or space having a volume exceeding 1 cubic foot for each 10 Btu/h (9.6 L/W) of combined input rating of all fuel-burning *appliances* therein.
 - 2.2. The volume of supply air discharged back into the same space shall be approximately equal to the volume of return air taken from the space.
 - 2.3. Return-air inlets shall not be located within 10 feet (3048 mm) of a *draft hood* in the same room or space or the combustion chamber of any atmospheric burner *appliance*, *including factory-built and masonry fireplaces* in the same room or space.
3. Rooms or spaces containing solid fuel-burning *appliances*, provided that return-air inlets are located not less than 10 feet (3048 mm) from the firebox of such appliances, *including factory-built and masonry fireplaces*.

6. A closet, bathroom, toilet room, kitchen, garage, boiler room, furnace room, **crawl space** or unconditioned attic.

Exceptions:

1. Where return air intakes are located not less than 10 feet (3048 mm) from cooking **appliances** and **serve only the kitchen area**, taking return air from a kitchen area shall not be prohibited.
2. Dedicated forced-air systems serving only a garage shall not be prohibited from obtaining return air from the garage.

~~7. A crawl space by means of direct connection to the return side of a forced air system. Transfer openings in the crawl space enclosure shall not be prohibited. Deleted.~~

G2442.54 (618.4) Screen. Required outdoor air inlets shall be covered with a screen having 1/4-inch (6.4 mm) openings.

G2442.65 (618.5) Return-air limitation. Return air from one *dwelling unit* shall not be discharged into another *dwelling unit*.

G2442.76 (618.6) Furnace plenums and air ducts. Where a *furnace* is installed so that supply ducts carry air circulated by the *furnace* to areas outside of the space containing the *furnace*, the return air shall be handled by a duct(s) sealed to the *furnace* casing and terminating outside of the space containing the *furnace*.

G2442.7.1 (618.8) Refrigeration coils in warm-air furnaces. When a cooling coil is located in the supply plenum of a warm-air furnace, the furnace blower shall be rated at not less than 0.5-inch water column (124 Pa) static pressure unless the furnace is *listed* and *labeled* for use with a cooling coil. Cooling coils shall not be located upstream from *heat exchangers* unless *listed* and *labeled* for such use. Conversion of existing furnaces for use with cooling coils shall be permitted, provided the furnace will operate within the temperature rise specified for the furnace.

G2442.7.2 (618.9) Return air intake (nonengineered systems). If only one central return air grille is installed, it shall be of a size sufficient to return a volume of air compatible with the cubic foot per minute requirements and the temperature rise limitations specified by the equipment manufacturer. The face velocity of return air grilles shall not exceed 450 feet per minute (fpm) (2.3 m/s). At least one separate return shall be installed on each level of a multilevel structure. For split level and split foyer structures, one return may serve more than one level if located within the split area and the total area of the levels does not exceed 1,600 square feet (148.6 m²). Return air grilles shall not be located in bathrooms. The return air from one residential living unit shall not be mixed with the return air from other living units. In dwellings with 1,600 square feet (148.6 m²) or less of conditioned area, a central return is permitted. When the dwelling contains more than 1,600 square feet (148.6 m²) of conditioned area, additional returns shall be provided. Each return shall serve not more than 1,600 square feet (148.6 m²) of area and shall be located in the area it serves. Return air may travel through the living space to the return air intake if there are no restrictions, such as solid doors, to the air movement. Undercut doors are allowed. When panned joists are used for return air, the structural integrity shall be maintained. Air capacity for joists 16 inches (406 mm) on center shall be a maximum of 375 cubic feet per minute (0.177 m³/s) for 8-inch (203 mm) joists and 525 cubic feet per minute (0.248 m³/s) for 10-inch (254 mm) joists. Wiring located in spaces used for return air ducts shall comply with the *North Carolina Electrical Code*.

SECTION G2443 (619) CONVERSION BURNERS

G2443.1 (619.1) Conversion burners. The installation of *conversion burners* shall conform to ANSI Z21.8.

SECTION G2444 (620) UNIT HEATERS

G2444.1 (620.1) General. *Unit heaters* shall be *listed* in accordance with ANSI Z83.8/CSA 2.6 and shall be installed in accordance with the manufacturer's instructions.

G2444.2 (620.2) Support. Suspended-type *unit heaters* shall be supported by elements that are designed and constructed to accommodate the weight and dynamic loads. Hangers and brackets shall be of **noncombustible material**.

G2444.3 (620.3) Ductwork. Ducts shall not be connected to a unit heater unless the heater is *listed* for such installation.

G2444.4 (620.4) Clearance. Suspended-type *unit heaters* shall be installed with *clearances to combustible materials* 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 mm) above the top of the sloping side of the vertical *draft hood*.

Floor-mounted-type *unit heaters* shall be installed with *clearances to combustible materials* at the back and one side only 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. Floor-mounted-type *unit heaters* shall not be installed on combustible floors unless *listed* for such installation.

Clearances for servicing all *unit heaters* shall be in accordance with the manufacturer's installation instructions.

Exception: *Unit heaters listed* for reduced *clearance* shall be permitted to be installed with such *clearances* in accordance with their listing and the manufacturer's instructions.

SECTION G2445 (621) UNVENTED ROOM HEATERS

G2445.1 (621.1) General. *Unvented room heaters* shall be *listed* in accordance with ANSI Z21.11.2 and shall be installed in accordance with the conditions of the listing and the manufacturer's instructions.

G2445.2 (621.2) Prohibited use. One or more *unvented room heaters* shall not be used as the sole source of comfort heating in a *dwelling unit*.

G2445.3 (621.3) Input rating. *Unvented room heaters* shall not have an input rating in excess of 40,000 *Btu/h* (11.7 kW).

G2445.4 (621.4) Prohibited locations. The location of *unvented room heaters* shall comply with Section G2406.2.

G2445.5 (621.5) Room or space volume. The aggregate input rating of all *unvented appliances* installed in a room or space shall not exceed 20 *Btu/h* per *cubic foot* (207 W/m³) of volume of such room or space. Where the room or space in which the *appliances* are installed is directly connected to another room or space by a doorway, archway or other opening of comparable size that cannot be closed, the volume of such adjacent room or space shall be permitted to be included in the calculations.

G2445.6 (621.6) Oxygen-depletion safety system. *Unvented room heaters* shall be equipped with an oxygen-depletion-sensitive safety shutoff system. The system shall shut off the gas supply to the main and *pilot burners* when the oxygen in the surrounding atmosphere is depleted to the percent concentration specified by the manufacturer, but not lower than 18 percent. The system shall not incorporate field adjustment means capable of changing the set point at which the system acts to shut off the gas supply to the room heater.

G2445.7 (621.7) Unvented decorative (log) room heaters. An unvented decorative room heater shall not be installed in a *factory-built fireplace* unless the *fireplace* system has been specifically tested, *listed* and *labeled* for such use in accordance with UL 127.

G2445.7.1 (621.7.1) Ventless firebox enclosures. Ventless firebox enclosures used with unvented decorative (log) room heaters shall be *listed* as complying with ANSI Z21.91.

SECTION G2446 (622) VENTED ROOM HEATERS

G2446.1 (622.1) General. *Vented room heaters* shall be *listed* in accordance with ANSI Z21.86/CSA 2.32, shall be designed and equipped as specified in Section G2432.2 and shall be installed in accordance with the manufacturer's instructions.

SECTION G2447 (623) COOKING APPLIANCES

G2447.1 (623.1) Cooking appliances. Cooking *appliances* that are designed for permanent installation, including ranges, ovens, stoves, broilers, grills, fryers, griddles, hot plates and barbecues, shall be *listed* in accordance with ANSI Z21.1 or ANSI Z21.58/CSA 1.6 and shall be installed in accordance with the manufacturer's instructions.

G2447.2 (623.2) Prohibited location. Cooking *appliances* designed, tested, *listed* and *labeled* for use in commercial occupancies shall not be installed within *dwelling units* or within any area where domestic cooking operations occur.

Exception: *Appliances* that are also *listed* as domestic cooking *appliances*. □

G2447.3 (623.3) Domestic appliances. Cooking *appliances* installed within *dwelling units* and within areas where domestic cooking operations occur shall be *listed* and *labeled* as household-type *appliances* for domestic use.

G2447.4 (623.4) Range installation. Ranges installed on combustible floors shall be set on their own bases or legs and shall be installed with *clearances* of not less than that shown on the *label*.

G2447.5 (623.7) Vertical clearance above cooking top. Household cooking *appliances* shall have a vertical *clearance* above the cooking top of not less than 30 inches (760 mm) to *combustible material* and metal cabinets. A minimum *clearance* of 24 inches (610 mm) is permitted where one of the following is installed:

1. The underside of the *combustible material* or metal cabinet above the cooking top is protected with not less than 1/4-inch (6.4 mm) insulating millboard covered with sheet metal not less than 0.0122 inch (0.3 mm) thick.
2. A metal ventilating hood constructed of sheet metal not less than 0.0122 inch (0.3 mm) thick is installed above the cooking top with a *clearance* of not less than 1/4 inch (6.4 mm) between the hood and the underside of the *combustible material* or metal cabinet. The hood shall have a width not less than the width of the *appliance* and shall be centered over the *appliance*.
3. A *listed* cooking *appliance* or microwave oven is installed over a *listed* cooking *appliance* and in compliance with the terms of the manufacturer's installation instructions for the upper *appliance*.

SECTION G2448 (624) WATER HEATERS

G2448.1 (624.1) General. Water heaters shall be *listed* in accordance with ANSI Z21.10.1/CSA 4.1 or ANSI Z21.10.3/CSA 4.3 and shall be installed in accordance with the manufacturer's instructions.

G2448.1.1 (624.1.1) Installation requirements. The requirements for *water heaters* relative to sizing, *relief valves*, drain pans and scald protection shall be in accordance with this code.

G2448.2 (624.2) Water heaters utilized for space heating. *Water heaters* utilized both to supply potable hot water and provide hot water for space-heating applications shall be *listed* and *labeled* for such applications by the manufacturer and shall be installed in accordance with the manufacturer's instructions and this code.

SECTION G2449 (627) AIR-CONDITIONING APPLIANCES

G2449.1 (627.1) General. Gas-fired air-conditioning *appliances* shall be *listed* in accordance with ANSI Z21.40.1/CSA 2.91 or ANSI Z21.40.2/CSA 2.92 and shall be installed in accordance with the manufacturer's instructions.

G2449.2 (627.2) Independent piping. *Gas piping* serving heating *appliances* shall be permitted to also serve cooling *appliances* where such heating and cooling *appliances* cannot be operated simultaneously (see Section G2413).

G2449.3 (627.3) 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*.

G2449.4 (627.6) Installation. Air-conditioning *appliances* shall be installed in accordance with the manufacturer's 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, the *appliance* shall be installed on a surface of noncombustible construction with *noncombustible material* and surface finish, and *combustible material* shall not be against the underside thereof.

SECTION G2450 (628)
ILLUMINATING APPLIANCES

G2450.1 (628.1) General. Illuminating *appliances* shall be *listed* in accordance with ANSI Z21.42 and shall be installed in accordance with the manufacturer's instructions.

G2450.2 (628.2) Mounting on buildings. Illuminating *appliances* designed for wall or ceiling mounting shall be securely attached to substantial structures in such a manner that they are not dependent on the *gas piping* for support.

G2450.3 (628.3) Mounting on posts. Illuminating *appliances* designed for post mounting shall be securely and rigidly attached to a post. Posts shall be rigidly mounted. The strength and rigidity of posts greater than 3 feet (914 mm) in height shall be at least equivalent to that of a 2¹/₂-inch-diameter (64 mm) post constructed of 0.064-inch-thick (1.6 mm) steel or a 1-inch (25 mm) Schedule 40 steel *pipe*. Posts 3 feet (914 mm) or less in height shall not be smaller than a ³/₄-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.

G2450.4 (628.4) 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 to the illuminating *appliance*. For multiple installations, one *regulator* of adequate capacity shall be permitted to serve more than one illuminating *appliance*.

SECTION G2451 (630)
INFRARED RADIANT HEATERS

G2451.1 (630.1) General. Infrared radiant heaters shall be *listed* in accordance with ANSI Z83.19 or Z83.20 and shall be installed in accordance with the manufacturer's instructions.

G2451.2 (630.2) Support. *Infrared radiant heaters* shall be fixed in a position independent of gas and electric supply lines. Hangers and brackets shall be of *noncombustible material*.

SECTION G2452 (634)
BOILERS

G2452.1 (631.1) Standards. Boilers shall be *listed* in accordance with the requirements of ANSI Z21.13/CSA 4.9 or UL 795. If applicable, the boiler shall be designed and constructed in accordance with the requirements of ASME CSD-1 and as applicable, the *ASME Boiler and Pressure Vessel Code*, Sections I, II, IV, V and IX and NFPA 85.

G2452.2 (631.2) Installation. In addition to the requirements of this code, the installation of boilers shall be in accordance with the manufacturer's instructions. Operating instructions of a permanent type shall be attached to the boiler. Boilers shall have all *controls* set, adjusted and tested by the installer. A complete *control* diagram together with complete boiler operating instructions shall be furnished by the installer. The manufacturer's rating data and the nameplate shall be attached to the boiler.

G2452.3 (631.3) Clearance to combustible material. *Clearances to combustible materials* shall be in accordance with Section G2409.4. □

SECTION G2453 (635)
OUTDOOR DECORATIVE APPLIANCES

G2453.1 (635.1) General. Permanently fixed-in-place outdoor decorative *appliances* shall be *listed* in accordance with ANSI Z21.97 and shall be installed in accordance with the manufacturer's instructions.

SECTION G2454 (646)
ENGINE AND GAS
TURBINE-POWERED EQUIPMENT

G2454.1 (646.1) Powered equipment. Permanently installed *equipment* powered by internal combustion engines and turbines shall be installed in accordance with the manufacturer's instructions and NFPA 37. Stationary engine generator assemblies shall meet the requirements of UL 2200.

G2454.2 (616.2) Gas supply connection. *Equipment* powered by internal combustion engines and turbines shall not be rigidly connected to the gas supply piping.

**TABLE G2413.4(1) [402.4(2)]
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	Less than 2 psi
Pressure Drop	0.5 in. w.c.
Specific Gravity	0.60

PIPE SIZE (inches)														
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10	12
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	6.065	7.981	10.020	11.938
Length (ft)	Capacity in Cubic Feet of Gas per Hour													
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	67,600	139,000	252,000	399,000
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	46,500	95,500	173,000	275,000
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	37,300	76,700	139,000	220,000
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	31,900	65,600	119,000	189,000
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	28,300	58,200	106,000	167,000
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	25,600	52,700	95,700	152,000
70	60	126	237	486	728	1,400	2,230	3,950	8,050	14,600	23,600	48,500	88,100	139,000
80	56	117	220	452	677	1,300	2,080	3,670	7,490	13,600	22,000	45,100	81,900	130,000
90	52	110	207	424	635	1,220	1,950	3,450	7,030	12,700	20,600	42,300	76,900	122,000
100	50	104	195	400	600	1,160	1,840	3,260	6,640	12,000	19,500	40,000	72,600	115,000
125	44	92	173	355	532	1,020	1,630	2,890	5,890	10,600	17,200	35,400	64,300	102,000
150	40	83	157	322	482	928	1,480	2,610	5,330	9,650	15,600	32,100	58,300	92,300
175	37	77	144	296	443	854	1,360	2,410	4,910	8,880	14,400	29,500	53,600	84,900
200	34	71	134	275	412	794	1,270	2,240	4,560	8,260	13,400	27,500	49,900	79,000
250	30	63	119	244	366	704	1,120	1,980	4,050	7,320	11,900	24,300	44,200	70,000
300	27	57	108	221	331	638	1,020	1,800	3,670	6,630	10,700	22,100	40,100	63,400
350	25	53	99	203	305	587	935	1,650	3,370	6,100	9,880	20,300	36,900	58,400
400	23	49	92	189	283	546	870	1,540	3,140	5,680	9,190	18,900	34,300	54,300
450	22	46	86	177	266	512	816	1,440	2,940	5,330	8,620	17,700	32,200	50,900
500	21	43	82	168	251	484	771	1,360	2,780	5,030	8,150	16,700	30,400	48,100
550	20	41	78	159	239	459	732	1,290	2,640	4,780	7,740	15,900	28,900	45,700
600	19	39	74	152	228	438	699	1,240	2,520	4,560	7,380	15,200	27,500	43,600

650	18	38	71	145	218	420	669	1,180	2,410	4,360	7,070	14,500	26,400	41,800
700	17	36	68	140	209	403	643	1,140	2,320	4,190	6,790	14,000	25,300	40,100
750	17	35	66	135	202	389	619	1,090	2,230	4,040	6,540	13,400	24,400	38,600
800	16	34	63	130	195	375	598	1,060	2,160	3,900	6,320	13,000	23,600	37,300
850	16	33	61	126	189	363	579	1,020	2,090	3,780	6,110	12,600	22,800	36,100
900	15	32	59	122	183	352	561	992	2,020	3,660	5,930	12,200	22,100	35,000
950	15	31	58	118	178	342	545	963	1,960	3,550	5,760	11,800	21,500	34,000
1,000	14	30	56	115	173	333	530	937	1,910	3,460	5,600	11,500	20,900	33,100
1,100	14	28	53	109	164	316	503	890	1,810	3,280	5,320	10,900	19,800	31,400
1,200	13	27	51	104	156	301	480	849	1,730	3,130	5,070	10,400	18,900	30,000
1,300	12	26	49	100	150	289	460	813	1,660	3,000	4,860	9,980	18,100	28,700
1,400	12	25	47	96	144	277	442	781	1,590	2,880	4,670	9,590	17,400	27,600
1,500	11	24	45	93	139	267	426	752	1,530	2,780	4,500	9,240	16,800	26,600
1,600	11	23	44	89	134	258	411	727	1,480	2,680	4,340	8,920	16,200	25,600
1,700	11	22	42	86	130	250	398	703	1,430	2,590	4,200	8,630	15,700	24,800
1,800	10	22	41	84	126	242	386	682	1,390	2,520	4,070	8,370	15,200	24,100
1,900	10	21	40	81	122	235	375	662	1,350	2,440	3,960	8,130	14,800	23,400
2,000	NA	20	39	79	119	229	364	644	1,310	2,380	3,850	7,910	14,400	22,700

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

1. NA means a flow of less than 10 cfh.
2. Table entries have been rounded to three significant digits.

**TABLE G2413.4(2) [402.4(5)]
SCHEDULE 40 METALLIC PIPE**

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

PIPE SIZE (inches)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Capacity in Cubic Feet of Gas per Hour								
10	1,510	3,040	5,560	11,400	17,100	32,900	52,500	92,800	189,000
20	1,070	2,150	3,930	8,070	12,100	23,300	37,100	65,600	134,000
30	869	1,760	3,210	6,590	9,880	19,000	30,300	53,600	109,000
40	753	1,520	2,780	5,710	8,550	16,500	26,300	46,400	94,700
50	673	1,360	2,490	5,110	7,650	14,700	23,500	41,500	84,700
60	615	1,240	2,270	4,660	6,980	13,500	21,400	37,900	77,300
70	569	1,150	2,100	4,320	6,470	12,500	19,900	35,100	71,600
80	532	1,080	1,970	4,040	6,050	11,700	18,600	32,800	67,000
90	502	1,010	1,850	3,810	5,700	11,000	17,500	30,900	63,100
100	462	934	1,710	3,510	5,260	10,100	16,100	28,500	58,200

125	414	836	1,530	3,140	4,700	9,060	14,400	25,500	52,100
150	372	751	1,370	2,820	4,220	8,130	13,000	22,900	46,700
175	344	695	1,270	2,601	3,910	7,530	12,000	21,200	43,300
200	318	642	1,170	2,410	3,610	6,960	11,100	19,600	40,000
250	279	583	1,040	2,140	3,210	6,180	9,850	17,400	35,500
300	253	528	945	1,940	2,910	5,600	8,920	15,800	32,200
350	232	486	869	1,790	2,670	5,150	8,210	14,500	29,600
400	216	452	809	1,660	2,490	4,790	7,640	13,500	27,500
450	203	424	759	1,560	2,330	4,500	7,170	12,700	25,800
500	192	401	717	1,470	2,210	4,250	6,770	12,000	24,400
550	182	381	681	1,400	2,090	4,030	6,430	11,400	23,200
600	174	363	650	1,330	2,000	3,850	6,130	10,800	22,100
650	166	348	622	1,280	1,910	3,680	5,870	10,400	21,200
700	160	334	598	1,230	1,840	3,540	5,640	9,970	20,300
750	154	322	576	1,180	1,770	3,410	5,440	9,610	19,600
800	149	311	556	1,140	1,710	3,290	5,250	9,280	18,900
850	144	301	538	1,100	1,650	3,190	5,080	8,980	18,300
900	139	292	522	1,070	1,600	3,090	4,930	8,710	17,800
950	135	283	507	1,040	1,560	3,000	4,780	8,460	17,200
1,000	132	275	493	1,010	1,520	2,920	4,650	8,220	16,800
1,100	125	262	468	960	1,440	2,770	4,420	7,810	15,900
1,200	119	250	446	917	1,370	2,640	4,220	7,450	15,200
1,300	114	239	427	878	1,320	2,530	4,040	7,140	14,600
1,400	110	230	411	843	1,260	2,430	3,880	6,860	14,000
1,500	106	221	396	812	1,220	2,340	3,740	6,600	13,500
1,600	102	214	382	784	1,180	2,260	3,610	6,380	13,000
1,700	99	207	370	759	1,140	2,190	3,490	6,170	12,600
1,800	96	200	358	736	1,100	2,120	3,390	5,980	12,200
1,900	93	195	348	715	1,070	2,060	3,290	5,810	11,900
2,000	91	189	339	695	1,040	2,010	3,200	5,650	11,500

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(3) [402.4(9)]
SEMIRIGID COPPER TUBING**

Gas	Natural
Inlet Pressure	Less than 2 psi
Pressure Drop	0.5 in. w.c.
Specific Gravity	0.60

TUBE SIZE (inches)										
Nominal	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	—	—

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 (ft)	Capacity in Cubic Feet of Gas per Hour								
10	27	55	111	195	276	590	1,060	1,680	3,490
20	18	38	77	134	190	406	730	1,150	2,400
30	15	30	61	107	152	326	586	925	1,930
40	13	26	53	92	131	279	502	791	1,650
50	11	23	47	82	116	247	445	701	1,460
60	10	21	42	74	105	224	403	635	1,320
70	NA	19	39	68	96	206	371	585	1,220
80	NA	18	36	63	90	192	345	544	1,130
90	NA	17	34	59	84	180	324	510	1,060
100	NA	16	32	56	79	170	306	482	1,000
125	NA	14	28	50	70	151	271	427	890
150	NA	13	26	45	64	136	245	387	806
175	NA	12	24	41	59	125	226	356	742
200	NA	11	22	39	55	117	210	331	690
250	NA	NA	20	34	48	103	186	294	612
300	NA	NA	18	31	44	94	169	266	554
350	NA	NA	16	28	40	86	155	245	510
400	NA	NA	15	26	38	80	144	228	474
450	NA	NA	14	25	35	75	135	214	445
500	NA	NA	13	23	33	71	128	202	420
550	NA	NA	13	22	32	68	122	192	399
600	NA	NA	12	21	30	64	116	183	381
650	NA	NA	12	20	29	62	111	175	365
700	NA	NA	11	20	28	59	107	168	350
750	NA	NA	11	19	27	57	103	162	338
800	NA	NA	10	18	26	55	99	156	326
850	NA	NA	10	18	25	53	96	151	315
900	NA	NA	NA	17	24	52	93	147	306
950	NA	NA	NA	17	24	50	90	143	297
1,000	NA	NA	NA	16	23	49	88	139	289
1,100	NA	NA	NA	15	22	46	84	132	274
1,200	NA	NA	NA	15	21	44	80	126	262
1,300	NA	NA	NA	14	20	42	76	120	251
1,400	NA	NA	NA	13	19	41	73	116	241
1,500	NA	NA	NA	13	18	39	71	111	232
1,600	NA	NA	NA	13	18	38	68	108	224
1,700	NA	NA	NA	12	17	37	66	104	217
1,800	NA	NA	NA	12	17	36	64	101	210
1,900	NA	NA	NA	11	16	35	62	98	204

2,000	NA	NA	NA	11	16	34	60	95	199
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

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. NA means a flow of less than 10 cfh.
3. Table entries have been rounded to three significant digits

**TABLE G2413.4(4) [402.4(12)]
SEMIRIGID COPPER TUBING**

	Gas	Natural
Inlet Pressure	2.0 psi	
Pressure Drop	1.0 psi	
Specific Gravity	0.60	

TUBE SIZE (inches)										
Nominal	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	—	—
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 (ft)	Capacity in Cubic Feet of Gas per Hour									
10	245	506	1,030	1,800	2,550	5,450	9,820	15,500	32,200	
20	169	348	708	1,240	1,760	3,750	6,750	10,600	22,200	
30	135	279	568	993	1,410	3,010	5,420	8,550	17,800	
40	116	239	486	850	1,210	2,580	4,640	7,310	15,200	
50	103	212	431	754	1,070	2,280	4,110	6,480	13,500	
60	93	192	391	683	969	2,070	3,730	5,870	12,200	
70	86	177	359	628	891	1,900	3,430	5,400	11,300	
80	80	164	334	584	829	1,770	3,190	5,030	10,500	
90	75	154	314	548	778	1,660	2,990	4,720	9,820	
100	71	146	296	518	735	1,570	2,830	4,450	9,280	
125	63	129	263	459	651	1,390	2,500	3,950	8,220	
150	57	117	238	416	590	1,260	2,270	3,580	7,450	
175	52	108	219	383	543	1,160	2,090	3,290	6,850	
200	49	100	204	356	505	1,080	1,940	3,060	6,380	
250	43	89	181	315	448	956	1,720	2,710	5,650	
300	39	80	164	286	406	866	1,560	2,460	5,120	
350	36	74	150	263	373	797	1,430	2,260	4,710	
400	33	69	140	245	347	741	1,330	2,100	4,380	
450	31	65	131	230	326	696	1,250	1,970	4,110	
500	30	61	124	217	308	657	1,180	1,870	3,880	
550	28	58	118	206	292	624	1,120	1,770	3,690	
600	27	55	112	196	279	595	1,070	1,690	3,520	
650	26	53	108	188	267	570	1,030	1,620	3,370	
700	25	51	103	181	256	548	986	1,550	3,240	
750	24	49	100	174	247	528	950	1,500	3,120	
800	23	47	96	168	239	510	917	1,450	3,010	

850	22	46	93	163	231	493	888	1,400	2,920
900	22	44	90	158	224	478	861	1,360	2,830
950	21	43	88	153	217	464	836	1,320	2,740
1,000	20	42	85	149	211	452	813	1,280	2,670
1,100	19	40	81	142	201	429	772	1,220	2,540
1,200	18	38	77	135	192	409	737	1,160	2,420
1,300	18	36	74	129	183	392	705	1,110	2,320
1,400	17	35	71	124	176	376	678	1,070	2,230
1,500	16	34	68	120	170	363	653	1,030	2,140
1,600	16	33	66	116	164	350	630	994	2,070
1,700	15	31	64	112	159	339	610	962	2,000
1,800	15	30	62	108	154	329	592	933	1,940
1,900	14	30	60	105	149	319	575	906	1,890
2,000	14	29	59	102	145	310	559	881	1,830

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

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 have been rounded to three significant digits.

**TABLE G2413.4(5) [402.4(15)]
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Natural
Inlet Pressure	Less than 2 psi
Pressure Drop	0.5 in. w.c.
Specific Gravity	0.60

TUBE SIZE (EHD)														
Flow Designation	13	15	18	19	23	25	30	31	37	39	46	48	60	62
Length (ft)	Capacity in Cubic Feet of Gas per Hour													
5	46	63	115	134	225	270	471	546	895	1,037	1,790	2,070	3,660	4,140
10	32	44	82	95	161	192	330	383	639	746	1,260	1,470	2,600	2,930
15	25	35	66	77	132	157	267	310	524	615	1,030	1,200	2,140	2,400
20	22	31	58	67	116	137	231	269	456	536	888	1,050	1,850	2,080
25	19	27	52	60	104	122	206	240	409	482	793	936	1,660	1,860
30	18	25	47	55	96	112	188	218	374	442	723	856	1,520	1,700
40	15	21	41	47	83	97	162	188	325	386	625	742	1,320	1,470
50	13	19	37	42	75	87	144	168	292	347	559	665	1,180	1,320
60	12	17	34	38	68	80	131	153	267	318	509	608	1,080	1,200
70	11	16	31	36	63	74	121	141	248	295	471	563	1,000	1,110
80	10	15	29	33	60	69	113	132	232	277	440	527	940	1,040
90	10	14	28	32	57	65	107	125	219	262	415	498	887	983

100	9	13	26	30	54	62	101	118	208	249	393	472	843	933
150	7	10	20	23	42	48	78	91	171	205	320	387	691	762
200	6	9	18	21	38	44	71	82	148	179	277	336	600	661
250	5	8	16	19	34	39	63	74	133	161	247	301	538	591
300	5	7	15	17	32	36	57	67	95	148	226	275	492	540

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

1. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings 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 or bends.
2. 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.
3. Table entries have been rounded to three significant digits.

**TABLE G2413.4(6) [402.4(18)]
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Natural
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	0.60

TUBE SIZE (EHD)														
Flow Designation	13	15	18	19	23	25	30	31	37	39	46	48	60	62
Length (ft)	Capacity in Cubic Feet of Gas Per Hour													
10	270	353	587	700	1,100	1,370	2,590	2,990	4,510	5,037	9,600	10,700	18,600	21,600
25	166	220	374	444	709	876	1,620	1,870	2,890	3,258	6,040	6,780	11,900	13,700
30	151	200	342	405	650	801	1,480	1,700	2,640	2,987	5,510	6,200	10,900	12,500
40	129	172	297	351	567	696	1,270	1,470	2,300	2,605	4,760	5,380	9,440	10,900
50	115	154	266	314	510	624	1,140	1,310	2,060	2,343	4,260	4,820	8,470	9,720
75	93	124	218	257	420	512	922	1,070	1,690	1,932	3,470	3,950	6,940	7,940
80	89	120	211	249	407	496	892	1,030	1,640	1,874	3,360	3,820	6,730	7,690
100	79	107	189	222	366	445	795	920	1,470	1,685	3,000	3,420	6,030	6,880
150	64	87	155	182	302	364	646	748	1,210	1,389	2,440	2,800	4,940	5,620
200	55	75	135	157	263	317	557	645	1,050	1,212	2,110	2,430	4,290	4,870
250	49	67	121	141	236	284	497	576	941	1,090	1,890	2,180	3,850	4,360
300	44	61	110	129	217	260	453	525	862	999	1,720	1,990	3,520	3,980
400	38	52	96	111	189	225	390	453	749	871	1,490	1,730	3,060	3,450
500	34	46	86	100	170	202	348	404	552	783	1,330	1,550	2,740	3,090

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds $\frac{3}{4}$ psi, DO NOT USE THIS TABLE. Consult with the regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator can vary with flow rate.

2. CAUTION: Capacities shown in the table might exceed maximum capacity for a selected regulator. Consult with the regulator or tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings 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 or bends.
4. 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.
5. Table entries have been rounded to three significant digits.

**TABLE G2413.4(7) [402.4(24)]
POLYETHYLENE PLASTIC PIPE**

Gas	Natural
Inlet Pressure	Less than 2 psi
Pressure Drop	0.5 in. w.c.
Specific Gravity	0.60

PIPE SIZE (inches)						
Nominal OD	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9	SDR 11	SDR 11	SDR 10	SDR 11	SDR 11
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Capacity in Cubic Feet of Gas per Hour					
10	201	403	726	1,260	1,900	3,410
20	138	277	499	865	1,310	2,350
30	111	222	401	695	1,050	1,880
40	95	190	343	594	898	1,610
50	84	169	304	527	796	1,430
60	76	153	276	477	721	1,300
70	70	140	254	439	663	1,190
80	65	131	236	409	617	1,110
90	61	123	221	383	579	1,040
100	58	116	209	362	547	983
125	51	103	185	321	485	871
150	46	93	168	291	439	789
175	43	86	154	268	404	726
200	40	80	144	249	376	675
250	35	71	127	221	333	598
300	32	64	115	200	302	542
350	29	59	106	184	278	499
400	27	55	99	171	258	464
450	26	51	93	160	242	435
500	24	48	88	152	229	411

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(8) [402.4(22)]
POLYETHYLENE PLASTIC PIPE**

	Gas	Natural
Inlet Pressure	2.0 psi	
Pressure Drop	1.0 psi	
Specific Gravity	0.60	

PIPE SIZE (inches)						
Nominal OD	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9	SDR 11	SDR 11	SDR 10	SDR 11	SDR 11
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Capacity in Cubic Feet of Gas per Hour					
10	1,860	3,720	6,710	11,600	17,600	31,600
20	1,280	2,560	4,610	7,990	12,100	21,700
30	1,030	2,050	3,710	6,420	9,690	17,400
40	878	1,760	3,170	5,490	8,300	14,900
50	778	1,560	2,810	4,870	7,350	13,200
60	705	1,410	2,550	4,410	6,660	12,000
70	649	1,300	2,340	4,060	6,130	11,000
80	603	1,210	2,180	3,780	5,700	10,200
90	566	1,130	2,050	3,540	5,350	9,610
100	535	1,070	1,930	3,350	5,050	9,080
125	474	949	1,710	2,970	4,480	8,050
150	429	860	1,550	2,690	4,060	7,290
175	395	791	1,430	2,470	3,730	6,710
200	368	736	1,330	2,300	3,470	6,240
250	326	652	1,180	2,040	3,080	5,530
300	295	591	1,070	1,850	2,790	5,010
350	272	544	981	1,700	2,570	4,610
400	253	506	913	1,580	2,390	4,290
450	237	475	856	1,480	2,240	4,020
500	224	448	809	1,400	2,120	3,800
550	213	426	768	1,330	2,010	3,610
600	203	406	733	1,270	1,920	3,440
650	194	389	702	1,220	1,840	3,300
700	187	374	674	1,170	1,760	3,170
750	180	360	649	1,130	1,700	3,050
800	174	348	627	1,090	1,640	2,950
850	168	336	607	1,050	1,590	2,850
900	163	326	588	1,020	1,540	2,770
950	158	317	572	990	1,500	2,690
1,000	154	308	556	963	1,450	2,610

1,100	146	293	528	915	1,380	2,480
1,200	139	279	504	873	1,320	2,370
1,300	134	267	482	836	1,260	2,270
1,400	128	257	463	803	1,210	2,180
1,500	124	247	446	773	1,170	2,100
1,600	119	239	431	747	1,130	2,030
1,700	115	231	417	723	1,090	1,960
1,800	112	224	404	701	1,060	1,900
1,900	109	218	393	680	1,030	1,850
2,000	106	212	382	662	1,000	1,800

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(9) [402.4(25)]
SCHEDULE 40 METALLIC PIPE**

	Gas	Undiluted Propane
	Inlet Pressure	10.0 psi
	Pressure Drop	1.0 psi
	Specific Gravity	1.50

INTENDED USE: PIPE SIZING BETWEEN FIRST STAGE (high-pressure regulator) AND SECOND STAGE (low-pressure regulator)									
PIPE SIZE (inches)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Capacity in Thousands of Btu per Hour								
10	3,320	6,950	13,100	26,900	40,300	77,600	124,000	219,000	446,000
20	2,280	4,780	9,000	18,500	27,700	53,300	85,000	150,000	306,000
30	1,830	3,840	7,220	14,800	22,200	42,800	68,200	121,000	246,000
40	1,570	3,280	6,180	12,700	19,000	36,600	58,400	103,000	211,000
50	1,390	2,910	5,480	11,300	16,900	32,500	51,700	91,500	187,000
60	1,260	2,640	4,970	10,200	15,300	29,400	46,900	82,900	169,000
70	1,160	2,430	4,570	9,380	14,100	27,100	43,100	76,300	156,000
80	1,080	2,260	4,250	8,730	13,100	25,200	40,100	70,900	145,000
90	1,010	2,120	3,990	8,190	12,300	23,600	37,700	66,600	136,000
100	956	2,000	3,770	7,730	11,600	22,300	35,600	62,900	128,000
125	848	1,770	3,340	6,850	10,300	19,800	31,500	55,700	114,000
150	768	1,610	3,020	6,210	9,300	17,900	28,600	50,500	103,000
175	706	1,480	2,780	5,710	8,560	16,500	26,300	46,500	94,700
200	657	1,370	2,590	5,320	7,960	15,300	24,400	43,200	88,100
250	582	1,220	2,290	4,710	7,060	13,600	21,700	38,300	78,100
300	528	1,100	2,080	4,270	6,400	12,300	19,600	34,700	70,800
350	486	1,020	1,910	3,930	5,880	11,300	18,100	31,900	65,100
400	452	945	1,780	3,650	5,470	10,500	16,800	29,700	60,600
450	424	886	1,670	3,430	5,140	9,890	15,800	27,900	56,800

500	400	837	1,580	3,240	4,850	9,340	14,900	26,300	53,700
550	380	795	1,500	3,070	4,610	8,870	14,100	25,000	51,000
600	363	759	1,430	2,930	4,400	8,460	13,500	23,900	48,600
650	347	726	1,370	2,810	4,210	8,110	12,900	22,800	46,600
700	334	698	1,310	2,700	4,040	7,790	12,400	21,900	44,800
750	321	672	1,270	2,600	3,900	7,500	12,000	21,100	43,100
800	310	649	1,220	2,510	3,760	7,240	11,500	20,400	41,600
850	300	628	1,180	2,430	3,640	7,010	11,200	19,800	40,300
900	291	609	1,150	2,360	3,530	6,800	10,800	19,200	39,100
950	283	592	1,110	2,290	3,430	6,600	10,500	18,600	37,900
1,000	275	575	1,080	2,230	3,330	6,420	10,200	18,100	36,900
1,100	261	546	1,030	2,110	3,170	6,100	9,720	17,200	35,000
1,200	249	521	982	2,020	3,020	5,820	9,270	16,400	33,400
1,300	239	499	940	1,930	2,890	5,570	8,880	15,700	32,000
1,400	229	480	903	1,850	2,780	5,350	8,530	15,100	30,800
1,500	221	462	870	1,790	2,680	5,160	8,220	14,500	29,600
1,600	213	446	840	1,730	2,590	4,980	7,940	14,000	28,600
1,700	206	432	813	1,670	2,500	4,820	7,680	13,600	27,700
1,800	200	419	789	1,620	2,430	4,670	7,450	13,200	26,900
1,900	194	407	766	1,570	2,360	4,540	7,230	12,800	26,100
2,000	189	395	745	1,530	2,290	4,410	7,030	12,400	25,400

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(10) [402.4(26)]
SCHEDULE 40 METALLIC PIPE**

Gas	Undiluted Propane
Inlet Pressure	10.0 psi
Pressure Drop	3.0 psi
Specific Gravity	1.50

INTENDED USE: PIPE SIZING BETWEEN FIRST STAGE (high-pressure regulator) AND SECOND STAGE (low-pressure regulator)									
PIPE SIZE (inches)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Capacity in Thousands of Btu per Hour								
10	5,890	12,300	23,200	47,600	71,300	137,000	219,000	387,000	789,000
20	4,050	8,460	15,900	32,700	49,000	94,400	150,000	266,000	543,000
30	3,250	6,790	12,800	26,300	39,400	75,800	121,000	214,000	436,000
40	2,780	5,810	11,000	22,500	33,700	64,900	103,000	183,000	373,000
50	2,460	5,150	9,710	19,900	29,900	57,500	91,600	162,000	330,000
60	2,230	4,670	8,790	18,100	27,100	52,100	83,000	147,000	299,000
70	2,050	4,300	8,090	16,600	24,900	47,900	76,400	135,000	275,000
80	1,910	4,000	7,530	15,500	23,200	44,600	71,100	126,000	256,000

90	1,790	3,750	7,060	14,500	21,700	41,800	66,700	118,000	240,000
100	1,690	3,540	6,670	13,700	20,500	39,500	63,000	111,000	227,000
125	1,500	3,140	5,910	12,100	18,200	35,000	55,800	98,700	201,000
150	1,360	2,840	5,360	11,000	16,500	31,700	50,600	89,400	182,000
175	1,250	2,620	4,930	10,100	15,200	29,200	46,500	82,300	167,800
200	1,160	2,430	4,580	9,410	14,100	27,200	43,300	76,500	156,100
250	1,030	2,160	4,060	8,340	12,500	24,100	38,400	67,800	138,400
300	935	1,950	3,680	7,560	11,300	21,800	34,800	61,500	125,400
350	860	1,800	3,390	6,950	10,400	20,100	32,000	56,500	115,300
400	800	1,670	3,150	6,470	9,690	18,700	29,800	52,600	107,300
450	751	1,570	2,960	6,070	9,090	17,500	27,900	49,400	100,700
500	709	1,480	2,790	5,730	8,590	16,500	26,400	46,600	95,100
550	673	1,410	2,650	5,450	8,160	15,700	25,000	44,300	90,300
600	642	1,340	2,530	5,200	7,780	15,000	23,900	42,200	86,200
650	615	1,290	2,420	4,980	7,450	14,400	22,900	40,500	82,500
700	591	1,240	2,330	4,780	7,160	13,800	22,000	38,900	79,300
750	569	1,190	2,240	4,600	6,900	13,300	21,200	37,400	76,400
800	550	1,150	2,170	4,450	6,660	12,800	20,500	36,200	73,700
850	532	1,110	2,100	4,300	6,450	12,400	19,800	35,000	71,400
900	516	1,080	2,030	4,170	6,250	12,000	19,200	33,900	69,200
950	501	1,050	1,970	4,050	6,070	11,700	18,600	32,900	67,200
1,000	487	1,020	1,920	3,940	5,900	11,400	18,100	32,000	65,400
1,100	463	968	1,820	3,740	5,610	10,800	17,200	30,400	62,100
1,200	442	923	1,740	3,570	5,350	10,300	16,400	29,000	59,200
1,300	423	884	1,670	3,420	5,120	9,870	15,700	27,800	56,700
1,400	406	849	1,600	3,280	4,920	9,480	15,100	26,700	54,500
1,500	391	818	1,540	3,160	4,740	9,130	14,600	25,700	52,500
1,600	378	790	1,490	3,060	4,580	8,820	14,100	24,800	50,700
1,700	366	765	1,440	2,960	4,430	8,530	13,600	24,000	49,000
1,800	355	741	1,400	2,870	4,300	8,270	13,200	23,300	47,600
1,900	344	720	1,360	2,780	4,170	8,040	12,800	22,600	46,200
2,000	335	700	1,320	2,710	4,060	7,820	12,500	22,000	44,900

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(11) [402.4(27)]
SCHEDULE 40 METALLIC PIPE**

Gas	Undiluted Propane
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

INTENDED USE: PIPE SIZING BETWEEN 2 PSIG SERVICE AND LINE PRESSURE REGULATOR

PIPE SIZE (inches)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Capacity in Thousands of Btu per Hour								
10	2,680	5,590	10,500	21,600	32,400	62,400	99,500	176,000	359,000
20	1,840	3,850	7,240	14,900	22,300	42,900	68,400	121,000	247,000
30	1,480	3,090	5,820	11,900	17,900	34,500	54,900	97,100	198,000
40	1,260	2,640	4,980	10,200	15,300	29,500	47,000	83,100	170,000
50	1,120	2,340	4,410	9,060	13,600	26,100	41,700	73,700	150,000
60	1,010	2,120	4,000	8,210	12,300	23,700	37,700	66,700	136,000
70	934	1,950	3,680	7,550	11,300	21,800	34,700	61,400	125,000
80	869	1,820	3,420	7,020	10,500	20,300	32,300	57,100	116,000
90	815	1,700	3,210	6,590	9,880	19,000	30,300	53,600	109,000
100	770	1,610	3,030	6,230	9,330	18,000	28,600	50,600	103,000
125	682	1,430	2,690	5,520	8,270	15,900	25,400	44,900	91,500
150	618	1,290	2,440	5,000	7,490	14,400	23,000	40,700	82,900
175	569	1,190	2,240	4,600	6,890	13,300	21,200	37,400	76,300
200	529	1,110	2,080	4,280	6,410	12,300	19,700	34,800	71,000
250	469	981	1,850	3,790	5,680	10,900	17,400	30,800	62,900
300	425	889	1,670	3,440	5,150	9,920	15,800	27,900	57,000
350	391	817	1,540	3,160	4,740	9,120	14,500	25,700	52,400
400	364	760	1,430	2,940	4,410	8,490	13,500	23,900	48,800
450	341	714	1,340	2,760	4,130	7,960	12,700	22,400	45,800
500	322	674	1,270	2,610	3,910	7,520	12,000	21,200	43,200
550	306	640	1,210	2,480	3,710	7,140	11,400	20,100	41,100
600	292	611	1,150	2,360	3,540	6,820	10,900	19,200	39,200
650	280	585	1,100	2,260	3,390	6,530	10,400	18,400	37,500
700	269	562	1,060	2,170	3,260	6,270	9,990	17,700	36,000
750	259	541	1,020	2,090	3,140	6,040	9,630	17,000	34,700
800	250	523	985	2,020	3,030	5,830	9,300	16,400	33,500
850	242	506	953	1,960	2,930	5,640	9,000	15,900	32,400
900	235	490	924	1,900	2,840	5,470	8,720	15,400	31,500
950	228	476	897	1,840	2,760	5,310	8,470	15,000	30,500
1,000	222	463	873	1,790	2,680	5,170	8,240	14,600	29,700
1,100	210	440	829	1,700	2,550	4,910	7,830	13,800	28,200
1,200	201	420	791	1,620	2,430	4,680	7,470	13,200	26,900
1,300	192	402	757	1,550	2,330	4,490	7,150	12,600	25,800
1,400	185	386	727	1,490	2,240	4,310	6,870	12,100	24,800
1,500	178	372	701	1,440	2,160	4,150	6,620	11,700	23,900
1,600	172	359	677	1,390	2,080	4,010	6,390	11,300	23,000
1,700	166	348	655	1,340	2,010	3,880	6,180	10,900	22,300

1,800	161	337	635	1,300	1,950	3,760	6,000	10,600	21,600
1,900	157	327	617	1,270	1,900	3,650	5,820	10,300	21,000
2,000	152	318	600	1,230	1,840	3,550	5,660	10,000	20,400

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(12) [402.4(28)]
 SCHEDULE 40 METALLIC PIPE**

Gas	Undiluted Propane
Inlet Pressure	11.0 in. w.c.
Pressure Drop	0.5 in. w.c.
Specific Gravity	1.50

INTENDED USE: PIPE SIZING BETWEEN SINGLE- OR SECOND-STAGE (low pressure) REGULATOR AND APPLIANCE									
PIPE SIZE (inches)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026
Length (ft)	Capacity in Thousands of Btu per Hour								
10	291	608	1,150	2,350	3,520	6,790	10,800	19,100	39,000
20	200	418	787	1,620	2,420	4,660	7,430	13,100	26,800
30	160	336	632	1,300	1,940	3,750	5,970	10,600	21,500
40	137	287	541	1,110	1,660	3,210	5,110	9,030	18,400
50	122	255	480	985	1,480	2,840	4,530	8,000	16,300
60	110	231	434	892	1,340	2,570	4,100	7,250	14,800
80	101	212	400	821	1,230	2,370	3,770	6,670	13,600
100	94	197	372	763	1,140	2,200	3,510	6,210	12,700
125	89	185	349	716	1,070	2,070	3,290	5,820	11,900
150	84	175	330	677	1,010	1,950	3,110	5,500	11,200
175	74	155	292	600	899	1,730	2,760	4,880	9,950
200	67	140	265	543	814	1,570	2,500	4,420	9,010
250	62	129	243	500	749	1,440	2,300	4,060	8,290
300	58	120	227	465	697	1,340	2,140	3,780	7,710
350	51	107	201	412	618	1,190	1,900	3,350	6,840
400	46	97	182	373	560	1,080	1,720	3,040	6,190
450	42	89	167	344	515	991	1,580	2,790	5,700
500	40	83	156	320	479	922	1,470	2,600	5,300
550	37	78	146	300	449	865	1,380	2,440	4,970
600	35	73	138	283	424	817	1,300	2,300	4,700
650	33	70	131	269	403	776	1,240	2,190	4,460
700	32	66	125	257	385	741	1,180	2,090	4,260
750	30	64	120	246	368	709	1,130	2,000	4,080
800	29	61	115	236	354	681	1,090	1,920	3,920
850	28	59	111	227	341	656	1,050	1,850	3,770
900	27	57	107	220	329	634	1,010	1,790	3,640
950	26	55	104	213	319	613	978	1,730	3,530

1,000	25	53	100	206	309	595	948	1,680	3,420
1,100	25	52	97	200	300	578	921	1,630	3,320
1,200	24	50	95	195	292	562	895	1,580	3,230
1,300	23	48	90	185	277	534	850	1,500	3,070
1,400	22	46	86	176	264	509	811	1,430	2,930
1,500	21	44	82	169	253	487	777	1,370	2,800
1,200	24	50	95	195	292	562	895	1,580	3,230
1,300	23	48	90	185	277	534	850	1,500	3,070
1,400	22	46	86	176	264	509	811	1,430	2,930
1,500	21	44	82	169	253	487	777	1,370	2,800
1,600	20	42	79	162	243	468	746	1,320	2,690
1,700	19	40	76	156	234	451	719	1,270	2,590
1,800	19	39	74	151	226	436	694	1,230	2,500
1,900	18	38	71	146	219	422	672	1,190	2,420
2,000	18	37	69	142	212	409	652	1,150	2,350

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(13) [402.4(29)]
SEMIRIGID COPPER TUBING**

Gas	Undiluted Propane
Inlet Pressure	10.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

INTENDED USE: SIZING BETWEEN FIRST STAGE (high-pressure regulator) AND SECOND STAGE (low-pressure regulator)										
TUBE SIZE (inches)										
Nominal	K & L	1/4	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2	2
	ACR	3/8	1/2	5/8	3/4	7/8	1 1/8	1 3/8	—	—
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 (ft)	Capacity in Thousands of Btu per Hour									
10	513	1,060	2,150	3,760	5,330	11,400	20,500	32,300	67,400	
20	352	727	1,480	2,580	3,670	7,830	14,100	22,200	46,300	
30	283	584	1,190	2,080	2,940	6,290	11,300	17,900	37,200	
40	242	500	1,020	1,780	2,520	5,380	9,690	15,300	31,800	
50	215	443	901	1,570	2,230	4,770	8,590	13,500	28,200	
60	194	401	816	1,430	2,020	4,320	7,780	12,300	25,600	
70	179	369	751	1,310	1,860	3,980	7,160	11,300	23,500	
80	166	343	699	1,220	1,730	3,700	6,660	10,500	21,900	
90	156	322	655	1,150	1,630	3,470	6,250	9,850	20,500	
100	147	304	619	1,080	1,540	3,280	5,900	9,310	19,400	
125	131	270	549	959	1,360	2,910	5,230	8,250	17,200	
150	118	244	497	869	1,230	2,630	4,740	7,470	15,600	
175	109	225	457	799	1,130	2,420	4,360	6,880	14,300	
200	101	209	426	744	1,060	2,250	4,060	6,400	13,300	

250	90	185	377	659	935	2,000	3,600	5,670	11,800
300	81	168	342	597	847	1,810	3,260	5,140	10,700
350	75	155	314	549	779	1,660	3,000	4,730	9,840
400	70	144	292	511	725	1,550	2,790	4,400	9,160
450	65	135	274	480	680	1,450	2,620	4,130	8,590
500	62	127	259	453	643	1,370	2,470	3,900	8,120
550	59	121	246	430	610	1,300	2,350	3,700	7,710
600	56	115	235	410	582	1,240	2,240	3,530	7,350
650	54	111	225	393	558	1,190	2,140	3,380	7,040
700	51	106	216	378	536	1,140	2,060	3,250	6,770
750	50	102	208	364	516	1,100	1,980	3,130	6,520
800	48	99	201	351	498	1,060	1,920	3,020	6,290
850	46	96	195	340	482	1,030	1,850	2,920	6,090
900	45	93	189	330	468	1,000	1,800	2,840	5,910
950	44	90	183	320	454	970	1,750	2,750	5,730
1,000	42	88	178	311	442	944	1,700	2,680	5,580
1,100	40	83	169	296	420	896	1,610	2,540	5,300
1,200	38	79	161	282	400	855	1,540	2,430	5,050
1,300	37	76	155	270	383	819	1,470	2,320	4,840
1,400	35	73	148	260	368	787	1,420	2,230	4,650
1,500	34	70	143	250	355	758	1,360	2,150	4,480
1,600	33	68	138	241	343	732	1,320	2,080	4,330
1,700	32	66	134	234	331	708	1,270	2,010	4,190
1,800	31	64	130	227	321	687	1,240	1,950	4,060
1,900	30	62	126	220	312	667	1,200	1,890	3,940
2,000	29	60	122	214	304	648	1,170	1,840	3,830

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

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 have been rounded to three significant digits.

**TABLE G2413.4(14) [402.4(30)]
SEMIRIGID COPPER TUBING**

Gas	Undiluted Propane
Inlet Pressure	11.0 in. w.c.
Pressure Drop	0.5 in. w.c.
Specific Gravity	1.50

INTENDED USE: SIZING BETWEEN SINGLE- OR SECOND-STAGE (low-pressure regulator) AND APPLIANCE										
TUBE SIZE (inches)										
Nominal	K & L	¹ / ₄	³ / ₈	¹ / ₂	⁵ / ₈	³ / ₄	1	¹ / ₄	¹ / ₂	2
	ACR	³ / ₈	¹ / ₂	⁵ / ₈	³ / ₄	⁷ / ₈	¹ / ₈	¹ / ₈	—	—
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 (ft)	Capacity in Thousands of Btu per Hour									
10	45	93	188	329	467	997	1,800	2,830	5,890	

20	31	64	129	226	321	685	1,230	1,950	4,050
30	25	51	104	182	258	550	991	1,560	3,250
40	21	44	89	155	220	471	848	1,340	2,780
50	19	39	79	138	195	417	752	1,180	2,470
60	17	35	71	125	177	378	681	1,070	2,240
70	16	32	66	115	163	348	626	988	2,060
80	15	30	61	107	152	324	583	919	1,910
90	14	28	57	100	142	304	547	862	1,800
100	13	27	54	95	134	287	517	814	1,700
125	11	24	48	84	119	254	458	722	1,500
150	10	21	44	76	108	230	415	654	1,360
175	NA	20	40	70	99	212	382	602	1,250
200	NA	18	37	65	92	197	355	560	1,170
250	NA	16	33	58	82	175	315	496	1,030
300	NA	15	30	52	74	158	285	449	936
350	NA	14	28	48	68	146	262	414	861
400	NA	13	26	45	63	136	244	385	801
450	NA	12	24	42	60	127	229	361	752
500	NA	11	23	40	56	120	216	341	710
550	NA	11	22	38	53	114	205	324	674
600	NA	10	21	36	51	109	196	309	643
650	NA	NA	20	34	49	104	188	296	616
700	NA	NA	19	33	47	100	180	284	592
750	NA	NA	18	32	45	96	174	274	570
800	NA	NA	18	31	44	93	168	264	551
850	NA	NA	17	30	42	90	162	256	533
900	NA	NA	17	29	41	87	157	248	517
950	NA	NA	16	28	40	85	153	241	502
1,000	NA	NA	16	27	39	83	149	234	488
1,100	NA	NA	15	26	37	78	141	223	464
1,200	NA	NA	14	25	35	75	135	212	442
1,300	NA	NA	14	24	34	72	129	203	423
1,400	NA	NA	13	23	32	69	124	195	407
1,500	NA	NA	13	22	31	66	119	188	392
1,600	NA	NA	12	21	30	64	115	182	378
1,700	NA	NA	12	20	29	62	112	176	366
1,800	NA	NA	11	20	28	60	108	170	355
1,900	NA	NA	11	19	27	58	105	166	345
2,000	NA	NA	11	19	27	57	102	161	335

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

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. NA means a flow of less than 10,000 Btu/hr.
3. Table entries have been rounded to three significant digits.

**TABLE G2413.4(15) [402.4(31)]
SEMIRIGID COPPER TUBING**

	Gas	Undiluted Propane
	Inlet Pressure	2.0 psi
	Pressure Drop	1.0 psi
	Specific Gravity	1.50

INTENDED USE: TUBE SIZING BETWEEN 2 PSIG SERVICE AND LINE PRESSURE REGULATOR										
TUBE SIZE (inches)										
Nominal	K & L	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2
	ACR	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{3}{8}$	—	—
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 (ft)	Capacity in Thousands of Btu per Hour									
10	413	852	1,730	3,030	4,300	9,170	16,500	26,000	54,200	
20	284	585	1,190	2,080	2,950	6,310	11,400	17,900	37,300	
30	228	470	956	1,670	2,370	5,060	9,120	14,400	29,900	
40	195	402	818	1,430	2,030	4,330	7,800	12,300	25,600	
50	173	356	725	1,270	1,800	3,840	6,920	10,900	22,700	
60	157	323	657	1,150	1,630	3,480	6,270	9,880	20,600	
70	144	297	605	1,060	1,500	3,200	5,760	9,090	18,900	
80	134	276	562	983	1,390	2,980	5,360	8,450	17,600	
90	126	259	528	922	1,310	2,790	5,030	7,930	16,500	
100	119	245	498	871	1,240	2,640	4,750	7,490	15,600	
125	105	217	442	772	1,100	2,340	4,210	6,640	13,800	
150	95	197	400	700	992	2,120	3,820	6,020	12,500	
175	88	181	368	644	913	1,950	3,510	5,540	11,500	
200	82	168	343	599	849	1,810	3,270	5,150	10,700	
250	72	149	304	531	753	1,610	2,900	4,560	9,510	
300	66	135	275	481	682	1,460	2,620	4,140	8,610	
350	60	124	253	442	628	1,340	2,410	3,800	7,920	
400	56	116	235	411	584	1,250	2,250	3,540	7,370	
450	53	109	221	386	548	1,170	2,110	3,320	6,920	
500	50	103	209	365	517	1,110	1,990	3,140	6,530	
550	47	97	198	346	491	1,050	1,890	2,980	6,210	
600	45	93	189	330	469	1,000	1,800	2,840	5,920	
650	43	89	181	316	449	959	1,730	2,720	5,670	
700	41	86	174	304	431	921	1,660	2,620	5,450	
750	40	82	168	293	415	888	1,600	2,520	5,250	
800	39	80	162	283	401	857	1,540	2,430	5,070	
850	37	77	157	274	388	829	1,490	2,350	4,900	
900	36	75	152	265	376	804	1,450	2,280	4,750	
950	35	72	147	258	366	781	1,410	2,220	4,620	
1,000	34	71	143	251	356	760	1,370	2,160	4,490	

1,100	32	67	136	238	338	721	1,300	2,050	4,270
1,200	31	64	130	227	322	688	1,240	1,950	4,070
1,300	30	61	124	217	309	659	1,190	1,870	3,900
1,400	28	59	120	209	296	633	1,140	1,800	3,740
1,500	27	57	115	201	286	610	1,100	1,730	3,610
1,600	26	55	111	194	276	589	1,060	1,670	3,480
1,700	26	53	108	188	267	570	1,030	1,620	3,370
1,800	25	51	104	182	259	553	1,000	1,570	3,270
1,900	24	50	101	177	251	537	966	1,520	3,170
2,000	23	48	99	172	244	522	940	1,480	3,090

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

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 have been rounded to three significant digits.

**TABLE G2413.4(16) [402.4(32)]
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted Propane
Inlet Pressure	11.0 in. w.c.
Pressure Drop	0.5 in. w.c.
Specific Gravity	1.50

INTENDED USE: SIZING BETWEEN SINGLE OR SECOND STAGE (Low Pressure) REGULATOR AND THE APPLIANCE SHUTOFF VALVE														
TUBE SIZE (EHD)														
Flow Designation	13	15	18	19	23	25	30	31	37	39	46	48	60	62
Length (ft)	Capacity in Thousands of Btu per Hour													
5	72	99	181	211	355	426	744	863	1,420	1,638	2,830	3,270	5,780	6,550
10	50	69	129	150	254	303	521	605	971	1,179	1,990	2,320	4,110	4,640
15	39	55	104	121	208	248	422	490	775	972	1,620	1,900	3,370	3,790
20	34	49	91	106	183	216	365	425	661	847	1,400	1,650	2,930	3,290
25	30	42	82	94	164	192	325	379	583	762	1,250	1,480	2,630	2,940
30	28	39	74	87	151	177	297	344	528	698	1,140	1,350	2,400	2,680
40	23	33	64	74	131	153	256	297	449	610	988	1,170	2,090	2,330
50	20	30	58	66	118	137	227	265	397	548	884	1,050	1,870	2,080
60	19	26	53	60	107	126	207	241	359	502	805	961	1,710	1,900
70	17	25	49	57	99	117	191	222	330	466	745	890	1,590	1,760
80	15	23	45	52	94	109	178	208	307	438	696	833	1,490	1,650
90	15	22	44	50	90	102	169	197	286	414	656	787	1,400	1,550
100	14	20	41	47	85	98	159	186	270	393	621	746	1,330	1,480
150	11	15	31	36	66	75	123	143	217	324	506	611	1,090	1,210

200	9	14	28	33	60	69	112	129	183	283	438	531	948	1,050
250	8	12	25	30	53	61	99	117	163	254	390	476	850	934
300	8	11	23	26	50	57	90	107	147	234	357	434	777	854

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

1. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings 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 or bends.
2. 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.
3. Table entries have been rounded to three significant digits.

**TABLE G2413.4(17) [402.4(33)]
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted Propane
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

INTENDED USE: SIZING BETWEEN 2 PSI SERVICE AND THE LINE PRESSURE REGULATOR														
TUBE SIZE (EHD)														
Flow Designation	13	15	18	19	23	25	30	31	37	39	46	48	60	62
Length (ft)	Capacity in Thousands of Btu per Hour													
10	426	558	927	1,110	1,740	2,170	4,100	4,720	7,130	7,958	15,200	16,800	29,400	34,200
25	262	347	591	701	1,120	1,380	2,560	2,950	4,560	5,147	9,550	10,700	18,800	21,700
30	238	316	540	640	1,030	1,270	2,330	2,690	4,180	4,719	8,710	9,790	17,200	19,800
40	203	271	469	554	896	1,100	2,010	2,320	3,630	4,116	7,530	8,500	14,900	17,200
50	181	243	420	496	806	986	1,790	2,070	3,260	3,702	6,730	7,610	13,400	15,400
75	147	196	344	406	663	809	1,460	1,690	2,680	3,053	5,480	6,230	11,000	12,600
80	140	189	333	393	643	768	1,410	1,630	2,590	2,961	5,300	6,040	10,600	12,200
100	124	169	298	350	578	703	1,260	1,450	2,330	2,662	4,740	5,410	9,530	10,900
150	101	137	245	287	477	575	1,020	1,180	1,910	2,195	3,860	4,430	7,810	8,890
200	86	118	213	248	415	501	880	1,020	1,660	1,915	3,340	3,840	6,780	7,710
250	77	105	191	222	373	448	785	910	1,490	1,722	2,980	3,440	6,080	6,900
300	69	96	173	203	343	411	716	829	1,360	1,578	2,720	3,150	5,560	6,300
400	60	82	151	175	298	355	616	716	1,160	1,376	2,350	2,730	4,830	5,460
500	53	72	135	158	268	319	550	638	1,030	1,237	2,100	2,450	4,330	4,880

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

1. Table does not include effect of pressure drop across the line regulator. Where regulator loss exceeds 1/2 psi (based on 13 in. w.c. outlet pressure), DO NOT USE THIS TABLE. Consult with the regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator can vary with flow rate.

2. CAUTION: Capacities shown in the table might exceed maximum capacity for a selected regulator. Consult with the regulator or tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings 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 or bends.
4. 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.
5. Table entries have been rounded to three significant digits.

**TABLE G2413.4(18) [402.4(34)]
CORRUGATED STAINLESS STEEL TUBING (CSST)**

Gas	Undiluted Propane
Inlet Pressure	5.0 psi
Pressure Drop	3.5 psi
Specific Gravity	1.50

TUBE SIZE (EHD)														
Flow Designation	13	15	18	19	23	25	30	31	37	39	46	48	60	62
Length (ft)	Capacity in Thousands of Btu per Hour													
10	826	1,070	1,710	2,060	3,150	4,000	7,830	8,950	13,100	14,441	28,600	31,200	54,400	63,800
25	509	664	1,090	1,310	2,040	2,550	4,860	5,600	8,400	9,339	18,000	19,900	34,700	40,400
30	461	603	999	1,190	1,870	2,340	4,430	5,100	7,680	8,564	16,400	18,200	31,700	36,900
40	396	520	867	1,030	1,630	2,030	3,820	4,400	6,680	7,469	14,200	15,800	27,600	32,000
50	352	463	777	926	1,460	1,820	3,410	3,930	5,990	6,717	12,700	14,100	24,700	28,600
75	284	376	637	757	1,210	1,490	2,770	3,190	4,920	5,539	10,300	11,600	20,300	23,400
80	275	363	618	731	1,170	1,450	2,680	3,090	4,770	5,372	9,990	11,200	19,600	22,700
100	243	324	553	656	1,050	1,300	2,390	2,760	4,280	4,830	8,930	10,000	17,600	20,300
150	196	262	453	535	866	1,060	1,940	2,240	3,510	3,983	7,270	8,210	14,400	16,600
200	169	226	393	464	755	923	1,680	1,930	3,050	3,474	6,290	7,130	12,500	14,400
250	150	202	352	415	679	828	1,490	1,730	2,740	3,124	5,620	6,390	11,200	12,900
300	136	183	322	379	622	757	1,360	1,570	2,510	2,865	5,120	5,840	10,300	11,700
400	117	158	279	328	542	657	1,170	1,360	2,180	2,498	4,430	5,070	8,920	10,200
500	104	140	251	294	488	589	1,050	1,210	1,950	2,247	3,960	4,540	8,000	9,110

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Notes:

1. Table does not include effect of pressure drop across line regulator. Where regulator loss exceeds 1 psi, DO NOT USE THIS TABLE. Consult with the regulator manufacturer for pressure drops and capacity factors. Pressure drop across regulator can vary with the flow rate.
2. CAUTION: Capacities shown in the table might exceed maximum capacity of selected regulator. Consult with the tubing manufacturer for guidance.
3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings 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 or bends.
4. 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.
5. Table entries have been rounded to three significant digits.

**TABLE G2413.4(19) [402.4(35)]
POLYETHYLENE PLASTIC PIPE**

Gas	Undiluted Propane
Inlet Pressure	11.0 in. w.c.
Pressure Drop	0.5 in. w.c.
Specific Gravity	1.50

INTENDED USE: PE PIPE SIZING BETWEEN INTEGRAL 2-STAGE REGULATOR AT TANK OR SECOND STAGE (low-pressure regulator) AND BUILDING						
PIPE SIZE (inches)						
Nominal OD	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9	SDR 11	SDR 11	SDR 10	SDR 11	SDR 11
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Capacity in Thousands of Btu per Hour					
10	340	680	1,230	2,130	3,210	5,770
20	233	468	844	1,460	2,210	3,970
30	187	375	677	1,170	1,770	3,180
40	160	321	580	1,000	1,520	2,730
50	142	285	514	890	1,340	2,420
60	129	258	466	807	1,220	2,190
70	119	237	428	742	1,120	2,010
80	110	221	398	690	1,040	1,870
90	103	207	374	648	978	1,760
100	98	196	353	612	924	1,660
125	87	173	313	542	819	1,470
150	78	157	284	491	742	1,330
175	72	145	261	452	683	1,230
200	67	135	243	420	635	1,140
250	60	119	215	373	563	1,010
300	54	108	195	338	510	916
350	50	99	179	311	469	843
400	46	92	167	289	436	784
450	43	87	157	271	409	736
500	41	82	148	256	387	695

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(20) [402.4(36)]
POLYETHYLENE PLASTIC PIPE**

Gas	Undiluted Propane
Inlet Pressure	2.0 psi
Pressure Drop	1.0 psi

Specific Gravity 1.50

INTENDED USE: PE PIPE SIZING BETWEEN 2 PSIG SERVICE REGULATOR AND LINE PRESSURE REGULATOR

PIPE SIZE (inches)						
Nominal OD	1/2	3/4	1	1 1/4	1 1/2	2
Designation	SDR 9	SDR 11	SDR 11	SDR 10	SDR 11	SDR 11
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Capacity in Thousands of Btu per Hour					
10	3,130	6,260	11,300	19,600	29,500	53,100
20	2,150	4,300	7,760	13,400	20,300	36,500
30	1,730	3,450	6,230	10,800	16,300	29,300
40	1,480	2,960	5,330	9,240	14,000	25,100
50	1,310	2,620	4,730	8,190	12,400	22,200
60	1,190	2,370	4,280	7,420	11,200	20,100
70	1,090	2,180	3,940	6,830	10,300	18,500
80	1,010	2,030	3,670	6,350	9,590	17,200
90	952	1,910	3,440	5,960	9,000	16,200
100	899	1,800	3,250	5,630	8,500	15,300
125	797	1,600	2,880	4,990	7,530	13,500
150	722	1,450	2,610	4,520	6,830	12,300
175	664	1,330	2,400	4,160	6,280	11,300
200	618	1,240	2,230	3,870	5,840	10,500
250	548	1,100	1,980	3,430	5,180	9,300
300	496	994	1,790	3,110	4,690	8,430
350	457	914	1,650	2,860	4,320	7,760
400	425	851	1,530	2,660	4,020	7,220
450	399	798	1,440	2,500	3,770	6,770
500	377	754	1,360	2,360	3,560	6,390
550	358	716	1,290	2,240	3,380	6,070
600	341	683	1,230	2,140	3,220	5,790
650	327	654	1,180	2,040	3,090	5,550
700	314	628	1,130	1,960	2,970	5,330
750	302	605	1,090	1,890	2,860	5,140
800	292	585	1,050	1,830	2,760	4,960
850	283	566	1,020	1,770	2,670	4,800
900	274	549	990	1,710	2,590	4,650
950	266	533	961	1,670	2,520	4,520
1,000	259	518	935	1,620	2,450	4,400
1,100	246	492	888	1,540	2,320	4,170
1,200	234	470	847	1,470	2,220	3,980
1,300	225	450	811	1,410	2,120	3,810
1,400	216	432	779	1,350	2,040	3,660
1,500	208	416	751	1,300	1,960	3,530

1,600	201	402	725	1,260	1,900	3,410
1,700	194	389	702	1,220	1,840	3,300
1,800	188	377	680	1,180	1,780	3,200
1,900	183	366	661	1,140	1,730	3,110
2,000	178	356	643	1,110	1,680	3,020

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(21) [402.4(37)]
POLYETHYLENE PLASTIC TUBING**

Gas	Undiluted Propane
Inlet Pressure	11.0 in. w.c.
Pressure Drop	0.5 in. w.c.
Specific Gravity	1.50

INTENDED USE: PE PIPE SIZING BETWEEN INTEGRAL 2-STAGE REGULATOR AT TANK OR SECOND STAGE (low-pressure regulator) AND BUILDING

Plastic Tubing Size (CTS) (inch)		
Nominal OD	1/2	1
Designation	SDR 7	SDR 11
Actual ID	0.445	0.927
Length (ft)	Capacity in Cubic Feet of Gas per Hour	
10	121	828
20	83	569
30	67	457
40	57	391
50	51	347
60	46	314
70	42	289
80	39	269
90	37	252
100	35	238
125	31	211
150	28	191
175	26	176
200	24	164
225	22	154
250	21	145
275	20	138
300	19	132

350	18	121
400	16	113
450	15	106
500	15	100

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa,
1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

Note: Table entries have been rounded to three significant digits.

**TABLE G2413.4(22) [402.4(38)]
POLYETHYLENE PLASTIC TUBING**

Gas	Undiluted Propane
Inlet Pressure	10.0 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

INTENDED USE	PE pipe sizing between first stage and second stage regulator.					
PLASTIC TUBING SIZE (inches)						
Nominal OD	<u>1/2</u>	<u>3/4</u>	<u>1</u>	<u>1 1/4</u>	<u>1 1/2</u>	<u>2</u>
Designation	SDR 9.33	SDR 11	SDR 11	SDR 10	SDR 11	SDR 11
Actual ID	0.660	0.860	1.077	1.328	1.554	1.943
Length (ft)	Capacity In Thousands of Btu per Hour					
<u>10</u>	<u>3,836</u>	<u>7,680</u>	<u>13,857</u>	<u>24,007</u>	<u>36,254</u>	<u>65,140</u>
<u>20</u>	<u>2,636</u>	<u>4,239</u>	<u>7,648</u>	<u>16,500</u>	<u>24,917</u>	<u>44,770</u>
<u>30</u>	<u>2,143</u>	<u>4,292</u>	<u>7,744</u>	<u>13,416</u>	<u>20,260</u>	<u>36,402</u>
<u>40</u>	<u>1,835</u>	<u>3,673</u>	<u>6,628</u>	<u>11,482</u>	<u>17,340</u>	<u>31,155</u>
<u>50</u>	<u>1,626</u>	<u>3,256</u>	<u>5,874</u>	<u>10,176</u>	<u>15,368</u>	<u>27,612</u>
<u>60</u>	<u>1,473</u>	<u>2,950</u>	<u>5,322</u>	<u>9,220</u>	<u>13,924</u>	<u>25,019</u>
<u>70</u>	<u>1,355</u>	<u>2,714</u>	<u>4,896</u>	<u>8,483</u>	<u>12,810</u>	<u>23,017</u>
<u>80</u>	<u>1,261</u>	<u>2,525</u>	<u>4,555</u>	<u>7,891</u>	<u>11,918</u>	<u>21,413</u>
<u>90</u>	<u>1,183</u>	<u>2,369</u>	<u>4,274</u>	<u>7,404</u>	<u>11,182</u>	<u>20,091</u>
<u>100</u>	<u>1,117</u>	<u>2,238</u>	<u>4,037</u>	<u>6,994</u>	<u>10,562</u>	<u>18,978</u>
<u>125</u>	<u>990</u>	<u>1,983</u>	<u>3,578</u>	<u>6,199</u>	<u>9,361</u>	<u>16,820</u>
<u>150</u>	<u>897</u>	<u>1,797</u>	<u>3,242</u>	<u>5,616</u>	<u>8,482</u>	<u>15,240</u>
<u>175</u>	<u>826</u>	<u>1,653</u>	<u>2,983</u>	<u>5,167</u>	<u>7,803</u>	<u>14,020</u>
<u>200</u>	<u>678</u>	<u>1,539</u>	<u>2,775</u>	<u>4,807</u>	<u>7,259</u>	<u>13,043</u>
<u>225</u>	<u>721</u>	<u>1,443</u>	<u>2,603</u>	<u>4,510</u>	<u>6,811</u>	<u>12,238</u>
<u>250</u>	<u>681</u>	<u>1,363</u>	<u>2,459</u>	<u>4,260</u>	<u>6,434</u>	<u>11,560</u>
<u>275</u>	<u>646</u>	<u>1,294</u>	<u>2,336</u>	<u>4,046</u>	<u>6,111</u>	<u>10,979</u>

<u>300</u>	<u>617</u>	<u>1,235</u>	<u>2,228</u>	<u>3,860</u>	<u>5,830</u>	<u>10,474</u>
<u>350</u>	<u>567</u>	<u>1,136</u>	<u>2,050</u>	<u>3,551</u>	<u>5,363</u>	<u>9,636</u>
<u>400</u>	<u>528</u>	<u>1,057</u>	<u>1,907</u>	<u>3,304</u>	<u>4,989</u>	<u>8,965</u>
<u>450</u>	<u>495</u>	<u>992</u>	<u>1,789</u>	<u>3,100</u>	<u>4,681</u>	<u>8,411</u>
<u>500</u>	<u>468</u>	<u>937</u>	<u>1,690</u>	<u>2,928</u>	<u>4,422</u>	<u>7,945</u>
<u>600</u>	<u>424</u>	<u>849</u>	<u>1,531</u>	<u>2,653</u>	<u>4,007</u>	<u>7,199</u>
<u>700</u>	<u>390</u>	<u>781</u>	<u>1,409</u>	<u>2,441</u>	<u>3,686</u>	<u>6,623</u>
<u>800</u>	<u>363</u>	<u>726</u>	<u>1,311</u>	<u>2,271</u>	<u>3,429</u>	<u>6,161</u>
<u>900</u>	<u>340</u>	<u>682</u>	<u>1,230</u>	<u>2,131</u>	<u>3,217</u>	<u>5,781</u>
<u>1,000</u>	<u>322</u>	<u>644</u>	<u>1,162</u>	<u>2,012</u>	<u>3,039</u>	<u>5,461</u>
<u>1,500</u>	<u>258</u>	<u>517</u>	<u>933</u>	<u>1,616</u>	<u>2,441</u>	<u>4,385</u>
<u>2,000</u>	<u>221</u>	<u>443</u>	<u>798</u>	<u>1,383</u>	<u>2,089</u>	<u>3,753</u>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**TABLE G2413.4(23) [402.4(39)]
POLYETHYLENE PLASTIC TUBING**

Gas	Undiluted Propane
Inlet Pressure	10 psi
Pressure Drop	1.0 psi
Specific Gravity	1.50

INTENDED USE	PE pipe sizing between first stage and second stage regulator.	
	PLASTIC TUBING SIZE (CTS) (inches)	
Nominal OD	<u>1/2</u>	<u>1</u>
Designation	SDR 7	SDR 11.5
Actual ID	0.445	0.927
Length (ft)	Capacity In Thousands of Btu per Hour	
<u>10</u>	<u>1,364</u>	<u>9,350</u>
<u>20</u>	<u>938</u>	<u>6,427</u>
<u>30</u>	<u>762</u>	<u>5,225</u>
<u>40</u>	<u>653</u>	<u>4,472</u>
<u>50</u>	<u>578</u>	<u>3,964</u>
<u>60</u>	<u>524</u>	<u>3,591</u>

<u>70</u>	<u>482</u>	<u>3,304</u>
<u>80</u>	<u>448</u>	<u>3,074</u>
<u>90</u>	<u>421</u>	<u>2,884</u>
<u>100</u>	<u>397</u>	<u>2,724</u>
<u>125</u>	<u>352</u>	<u>2,414</u>
<u>150</u>	<u>319</u>	<u>2,188</u>
<u>175</u>	<u>294</u>	<u>2,013</u>
<u>200</u>	<u>273</u>	<u>1,872</u>
<u>225</u>	<u>256</u>	<u>1,757</u>
<u>250</u>	<u>242</u>	<u>1,659</u>
<u>275</u>	<u>230</u>	<u>1,576</u>
<u>300</u>	<u>219</u>	<u>1,503</u>
<u>350</u>	<u>202</u>	<u>1,383</u>
<u>400</u>	<u>188</u>	<u>1,287</u>
<u>450</u>	<u>176</u>	<u>1,207</u>
<u>500</u>	<u>166</u>	<u>1,140</u>
<u>600</u>	<u>151</u>	<u>1,033</u>
<u>700</u>	<u>139</u>	<u>951</u>
<u>800</u>	<u>129</u>	<u>884</u>
<u>900</u>	<u>121</u>	<u>830</u>
<u>1,000</u>	<u>114</u>	<u>784</u>
<u>1,500</u>	<u>92</u>	<u>629</u>
<u>2,000</u>	<u>79</u>	<u>539</u>

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square inch = 6.895 kPa, 1-inch water column = 0.2488 kPa, 1 British thermal unit per hour = 0.2931 W, 1 cubic foot per hour = 0.0283 m³/h, 1 degree = 0.01745 rad.

**TABLE G2428.2(1) [504.2(1)]
TYPE B DOUBLE-WALL GAS VENT**

Number of Appliances	Single
Appliance Type	Category I
Appliance Vent Connection	Connected directly to vent

HEIGHT (H) (feet)	LATERAL (L) (feet)	VENT DIAMETER (D)—inches																					
		3		4		5		6		7		8		9									
		APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																					
		FAN		NAT	FAN		NAT	FAN		NAT	FAN		NAT	FAN		NAT	FAN		NAT				
Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max			
6	0	0	78	46	0	152	86	0	251	141	0	375	205	0	524	285	0	698	370	0	897	470	

	2	13	51	36	18	97	67	27	157	105	32	232	157	44	321	217	53	425	285	63	543	370
	4	21	49	34	30	94	64	39	153	103	50	227	153	66	316	211	79	419	279	93	536	362
	6	25	46	32	36	91	61	47	149	100	59	223	149	78	310	205	93	413	273	110	530	354
8	0	0	84	50	0	165	94	0	276	155	0	415	235	0	583	320	0	780	415	0	1,006	537
	2	12	57	40	16	109	75	25	178	120	28	263	180	42	365	247	50	483	322	60	619	418
	5	23	53	38	32	103	71	42	171	115	53	255	173	70	356	237	83	473	313	99	607	407
	8	28	49	35	39	98	66	51	164	109	64	247	165	84	347	227	99	463	303	117	596	396
10	0	0	88	53	0	175	100	0	295	166	0	447	255	0	631	345	0	847	450	0	1,096	585
	2	12	61	42	17	118	81	23	194	129	26	289	195	40	402	273	48	533	355	57	684	457
	5	23	57	40	32	113	77	41	187	124	52	280	188	68	392	263	81	522	346	95	671	446
	10	30	51	36	41	104	70	54	176	115	67	267	175	88	376	245	104	504	330	122	651	427
15	0	0	94	58	0	191	112	0	327	187	0	502	285	0	716	390	0	970	525	0	1,263	682
	2	11	69	48	15	136	93	20	226	150	22	339	225	38	475	316	45	633	414	53	815	544
	5	22	65	45	30	130	87	39	219	142	49	330	217	64	463	300	76	620	403	90	800	529
	10	29	59	41	40	121	82	51	206	135	64	315	208	84	445	288	99	600	386	116	777	507
	15	35	53	37	48	112	76	61	195	128	76	301	198	98	429	275	115	580	373	134	755	491
20	0	0	97	61	0	202	119	0	349	202	0	540	307	0	776	430	0	1,057	575	0	1,384	752
	2	10	75	51	14	149	100	18	250	166	20	377	249	33	531	346	41	711	470	50	917	612
	5	21	71	48	29	143	96	38	242	160	47	367	241	62	519	337	73	697	460	86	902	599
	10	28	64	44	38	133	89	50	229	150	62	351	228	81	499	321	95	675	443	112	877	576
	15	34	58	40	46	124	84	59	217	142	73	337	217	94	481	308	111	654	427	129	853	557
	20	48	52	35	55	116	78	69	206	134	84	322	206	107	464	295	125	634	410	145	830	537
30	0	0	100	64	0	213	128	0	374	220	0	587	336	0	853	475	0	1,173	650	0	1,548	855
	2	9	81	56	13	166	112	14	283	185	18	432	280	27	613	394	33	826	535	42	1,072	700
	5	21	77	54	28	160	108	36	275	176	45	421	273	58	600	385	69	811	524	82	1,055	688
	10	27	70	50	37	150	102	48	262	171	59	405	261	77	580	371	91	788	507	107	1,028	668
	15	33	64	NA	44	141	96	57	249	163	70	389	249	90	560	357	105	765	490	124	1,002	648
	20	56	58	NA	53	132	90	66	237	154	80	374	237	102	542	343	119	743	473	139	977	628
	30	NA	NA	NA	73	113	NA	88	214	NA	104	346	219	131	507	321	149	702	444	171	929	594
50	0	0	101	67	0	216	134	0	397	232	0	633	363	0	932	518	0	1,297	708	0	1,730	952
	2	8	86	61	11	183	122	14	320	206	15	497	314	22	715	445	26	975	615	33	1,276	813
	5	20	82	NA	27	177	119	35	312	200	43	487	308	55	702	438	65	960	605	77	1,259	798
	10	26	76	NA	35	168	114	45	299	190	56	471	298	73	681	426	86	935	589	101	1,230	773
	15	59	70	NA	42	158	NA	54	287	180	66	455	288	85	662	413	100	911	572	117	1,203	747
	20	NA	NA	NA	50	149	NA	63	275	169	76	440	278	97	642	401	113	888	556	131	1,176	722
	30	NA	NA	NA	69	131	NA	84	250	NA	99	410	259	123	605	376	141	844	522	161	1,125	670

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

**TABLE G2428.2(2) [504.2(2)]
TYPE B DOUBLE-WALL GAS VENT**

Number of Appliances	Single
Appliance Type	Category I
Appliance Vent Connection	Single-wall metal connector

HEIGHT (H) (feet)	LATERAL (L) (feet)	VENT DIAMETER (D)—inches																											
		3		4		5		6		7		8		9		10		12											
		APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																											
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT	
Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max
6	0	38	77	45	59	151	85	85	249	140	126	373	204	165	522	284	211	695	369	267	894	469	371	1,118	569	537	1,639	849	
	2	39	51	36	60	96	66	85	156	104	123	231	156	159	320	213	201	423	284	251	541	368	347	673	453	498	979	648	
	4	NA	NA	33	74	92	63	102	152	102	146	225	152	187	313	208	237	416	277	295	533	360	409	664	443	584	971	638	
	6	NA	NA	31	83	89	60	114	147	99	163	220	148	207	307	203	263	409	271	327	526	352	449	656	433	638	962	627	
8	0	37	83	50	58	164	93	83	273	154	123	412	234	161	580	319	206	777	414	258	1,002	536	360	1,257	658	521	1,852	967	
	2	39	56	39	59	108	75	83	176	119	121	261	179	155	363	246	197	482	321	246	617	417	339	768	513	486	1,120	743	
	5	NA	NA	37	77	102	69	107	168	114	151	252	171	193	352	235	245	470	311	305	604	404	418	754	500	598	1,104	730	
	8	NA	NA	33	90	95	64	122	161	107	175	243	163	223	342	225	280	458	300	344	591	392	470	740	486	665	1,089	715	
10	0	37	87	53	57	174	99	82	293	165	120	444	254	158	628	344	202	844	449	253	1,093	584	351	1,373	718	507	2,031	1,057	
	2	39	61	41	59	117	80	82	193	128	119	287	194	153	400	272	193	531	354	242	681	456	332	849	559	475	1,242	848	
	5	52	56	39	76	111	76	105	185	122	148	277	186	190	388	261	241	518	344	299	667	443	409	834	544	584	1,224	825	
	10	NA	NA	34	97	100	68	132	171	112	188	261	171	237	369	241	296	497	325	363	643	423	492	808	520	688	1,194	788	
15	0	36	93	57	56	190	111	80	325	186	116	499	283	153	713	388	195	966	523	244	1,259	681	336	1,591	838	488	2,374	1,237	
	2	38	69	47	57	136	93	80	225	149	115	337	224	148	473	314	187	631	413	232	812	543	319	1,015	673	457	1,491	983	
	5	51	63	44	75	128	86	102	216	140	144	326	217	182	459	298	231	616	400	287	795	526	392	997	657	562	1,469	963	
	10	NA	NA	39	95	116	79	128	201	131	182	308	203	228	438	284	284	592	381	349	768	501	470	966	628	664	1,433	928	
	15	NA	NA	NA	NA	NA	72	158	186	124	220	290	192	272	418	269	334	568	367	404	742	484	540	937	601	750	1,399	894	
20	0	35	96	60	54	200	118	78	346	201	114	537	306	149	772	428	190	1,053	573	238	1,379	750	326	1,751	927	473	2,631	1,346	
	2	37	74	50	56	148	99	78	248	165	113	375	248	144	528	344	182	708	468	227	914	611	309	1,146	754	443	1,689	1,098	
	5	50	68	47	73	140	94	100	239	158	141	363	239	178	514	334	224	692	457	279	896	596	381	1,126	734	547	1,665	1,074	
	10	NA	NA	41	93	129	86	125	223	146	177	344	224	222	491	316	277	666	437	339	866	570	457	1,092	702	646	1,626	1,037	
	15	NA	NA	NA	NA	NA	80	155	208	136	216	325	210	264	469	301	325	640	419	393	838	549	526	1,060	677	730	1,587	1,005	

(H) (feet)		APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU/H																							
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT	
		Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max
6	1	22	37	26	35	66	46	46	106	72	58	164	104	77	225	142	92	296	185	109	376	237	128	466	289
	2	23	41	31	37	75	55	48	121	86	60	183	124	79	253	168	95	333	220	112	424	282	131	526	345
	3	24	44	35	38	81	62	49	132	96	62	199	139	82	275	189	97	363	248	114	463	317	134	575	386
8	1	22	40	27	35	72	48	49	114	76	64	176	109	84	243	148	100	320	194	118	408	248	138	507	303
	2	23	44	32	36	80	57	51	128	90	66	195	129	86	269	175	103	356	230	121	454	294	141	564	358
	3	24	47	36	37	87	64	53	139	101	67	210	145	88	290	198	105	384	258	123	492	330	143	612	402
10	1	22	43	28	34	78	50	49	123	78	65	189	113	89	257	154	106	341	200	125	436	257	146	542	314
	2	23	47	33	36	86	59	51	136	93	67	206	134	91	282	182	109	374	238	128	479	305	149	596	372
	3	24	50	37	37	92	67	52	146	104	69	220	150	94	303	205	111	402	268	131	515	342	152	642	417
15	1	21	50	30	33	89	53	47	142	83	64	220	120	88	298	163	110	389	214	134	493	273	162	609	333
	2	22	53	35	35	96	63	49	153	99	66	235	142	91	320	193	112	419	253	137	532	323	165	658	394
	3	24	55	40	36	102	71	51	163	111	68	248	160	93	339	218	115	445	286	140	565	365	167	700	444
20	1	21	54	31	33	99	56	46	157	87	62	246	125	86	334	171	107	436	224	131	552	285	158	681	347
	2	22	57	37	34	105	66	48	167	104	64	259	149	89	354	202	110	463	265	134	587	339	161	725	414
	3	23	60	42	35	110	74	50	176	116	66	271	168	91	371	228	113	486	300	137	618	383	164	764	466
30	1	20	62	33	31	113	59	45	181	93	60	288	134	83	391	182	103	512	238	125	649	305	151	802	372
	2	21	64	39	33	118	70	47	190	110	62	299	158	85	408	215	105	535	282	129	679	360	155	840	439
	3	22	66	44	34	123	79	48	198	124	64	309	178	88	423	242	108	555	317	132	706	405	158	874	494

COMMON VENT CAPACITY

VENT HEIGHT (H) (feet)	TYPE B DOUBLE-WALL COMMON VENT DIAMETER (D)—inches																				
	4		5		6		7		8		9		10								
	COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																				
	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT
6	92	81	65	140	116	103	204	161	147	309	248	200	404	314	260	547	434	335	672	520	410
8	101	90	73	155	129	114	224	178	163	339	275	223	444	348	290	602	480	378	740	577	465
10	110	97	79	169	141	124	243	194	178	367	299	242	477	377	315	649	522	405	800	627	495
15	125	112	91	195	164	144	283	228	206	427	352	280	556	444	365	753	612	465	924	733	565
20	136	123	102	215	183	160	314	255	229	475	394	310	621	499	405	842	688	523	1,035	826	640
30	152	138	118	244	210	185	361	297	266	547	459	360	720	585	470	979	808	605	1,209	975	740
50	167	153	134	279	244	214	421	353	310	641	547	423	854	706	550	1,164	977	705	1,451	1,188	860

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

Number of Appliances	Two or more
Appliances Type	Category I

TABLE G2428.3(2) [504.3(2)]
TYPE B DOUBLE-WALL VENT

Appliances Vent Connection Single-wall metal connector

VENT CONNECTOR CAPACITY																									
VENT HEIGHT (H) (feet)	CONNECTOR RISE (R) (feet)	SINGLE-WALL METAL VENT CONNECTOR DIAMETER (D)—inches																							
		3		4		5		6		7		8		9		10									
		APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU/H																							
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT	
Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max		
6	1	NA	NA	26	NA	NA	46	NA	NA	71	NA	NA	102	207	223	140	262	293	183	325	373	234	447	463	286
	2	NA	NA	31	NA	NA	55	NA	NA	85	168	182	123	215	251	167	271	331	219	334	422	281	458	524	344
	3	NA	NA	34	NA	NA	62	121	131	95	175	198	138	222	273	188	279	361	247	344	462	316	468	574	385
8	1	NA	NA	27	NA	NA	48	NA	NA	75	NA	NA	106	226	240	145	285	316	191	352	403	244	481	502	299
	2	NA	NA	32	NA	NA	57	125	126	89	184	193	127	234	266	173	293	353	228	360	450	292	492	560	355
	3	NA	NA	35	NA	NA	64	130	138	100	191	208	144	241	287	197	302	381	256	370	489	328	501	609	400
10	1	NA	NA	28	NA	NA	50	119	121	77	182	186	110	240	253	150	302	335	196	372	429	252	506	534	308
	2	NA	NA	33	84	85	59	124	134	91	189	203	132	248	278	183	311	369	235	381	473	302	517	589	368
	3	NA	NA	36	89	91	67	129	144	102	197	217	148	257	299	203	320	398	265	391	511	339	528	637	413
15	1	NA	NA	29	79	87	52	116	138	81	177	214	116	238	291	158	312	380	208	397	482	266	556	596	324
	2	NA	NA	34	83	94	62	121	150	97	185	230	138	246	314	189	321	411	248	407	522	317	568	646	387
	3	NA	NA	39	87	100	70	127	160	109	193	243	157	255	333	215	331	438	281	418	557	360	579	690	437
20	1	49	56	30	78	97	54	115	152	84	175	238	120	233	325	165	306	425	217	390	538	276	546	664	336
	2	52	59	36	82	103	64	120	163	101	182	252	144	243	346	197	317	453	259	400	574	331	558	709	403
	3	55	62	40	87	107	72	125	172	113	190	264	164	252	363	223	326	476	294	412	607	375	570	750	457
30	1	47	60	31	77	110	57	112	175	89	169	278	129	226	380	175	296	497	230	378	630	294	528	779	358
	2	51	62	37	81	115	67	117	185	106	177	290	152	236	397	208	307	521	274	389	662	349	541	819	425
	3	54	64	42	85	119	76	122	193	120	185	300	172	244	412	235	316	542	309	400	690	394	555	855	482
COMMON VENT CAPACITY																									
VENT HEIGHT (H) (feet)	TYPE B DOUBLE-WALL COMMON VENT DIAMETER (D)—inches																								
	4		5		6		7		8		9		10												
	COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																								
	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	
6	NA	78	64	NA	113	99	200	158	144	304	244	196	398	310	257	541	429	332	665	515	407				
8	NA	87	71	NA	126	111	218	173	159	331	269	218	436	342	285	592	473	373	730	569	460				
10	NA	94	76	163	137	120	237	189	174	357	292	236	467	369	309	638	512	398	787	617	487				
15	121	108	88	189	159	140	275	221	200	416	343	274	544	434	357	738	599	456	905	718	553				
20	131	118	98	208	177	156	305	247	223	463	383	302	606	487	395	824	673	512	1,013	808	626				
30	145	132	113	236	202	180	350	286	257	533	446	349	703	570	459	958	790	593	1,183	952	723				

50	159	145	128	268	233	208	406	337	296	622	529	410	833	686	535	1,139	954	689	1,418	1,157	838
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For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

TABLE G2428.3(3) [504.3(3)]
MASONRY CHIMNEY

Number of Appliances	Two or more
Appliances Type	Category I
Appliances Vent Connection	Type B double-wall connector

VENT CONNECTOR CAPACITY																											
VENT HEIGHT (H) (feet)	CONNECTOR RISE (R) (feet)	TYPE B DOUBLE-WALL VENT CONNECTOR DIAMETER (D)—inches																									
		3		4		5		6		7		8		9		10											
		APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU/H																									
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT			
Min		Max		Max		Min		Max		Max		Min		Max		Max		Min		Max		Max		Min		Max	
6	1	24	33	21	39	62	40	52	106	67	65	194	101	87	274	141	104	370	201	124	479	253	145	599	319		
	2	26	43	28	41	79	52	53	133	85	67	230	124	89	324	173	107	436	232	127	562	300	148	694	378		
	3	27	49	34	42	92	61	55	155	97	69	262	143	91	369	203	109	491	270	129	633	349	151	795	439		
8	1	24	39	22	39	72	41	55	117	69	71	213	105	94	304	148	113	414	210	134	539	267	156	682	335		
	2	26	47	29	40	87	53	57	140	86	73	246	127	97	350	179	116	473	240	137	615	311	160	776	394		
	3	27	52	34	42	97	62	59	159	98	75	269	145	99	383	206	119	517	276	139	672	358	163	848	452		
10	1	24	42	22	38	80	42	55	130	71	74	232	108	101	324	153	120	444	216	142	582	277	165	739	348		
	2	26	50	29	40	93	54	57	153	87	76	261	129	103	366	184	123	498	247	145	652	321	168	825	407		
	3	27	55	35	41	105	63	58	170	100	78	284	148	106	397	209	126	540	281	147	705	366	171	893	463		
15	1	24	48	23	38	93	44	54	154	74	72	277	114	100	384	164	125	511	229	153	658	297	184	824	375		
	2	25	55	31	39	105	55	56	174	89	74	299	134	103	419	192	128	558	260	156	718	339	187	900	432		
	3	26	59	35	41	115	64	57	189	102	76	319	153	105	448	215	131	597	292	159	760	382	190	960	486		
20	1	24	52	24	37	102	46	53	172	77	71	313	119	98	437	173	123	584	239	150	752	312	180	943	397		
	2	25	58	31	39	114	56	55	190	91	73	335	138	101	467	199	126	625	270	153	805	354	184	1,011	452		
	3	26	63	35	40	123	65	57	204	104	75	353	157	104	493	222	129	661	301	156	851	396	187	1,067	505		

COMMON VENT CAPACITY																								
VENT HEIGHT (H) (feet)	MINIMUM INTERNAL AREA OF MASONRY CHIMNEY FLUE (square inches)																							
	12		19		28		38		50		63		78		113									
	COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																							
	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT
6	NA	74	25	NA	119	46	NA	178	71	NA	257	103	NA	351	143	NA	458	188	NA	582	246	1,041	853	NA
8	NA	80	28	NA	130	53	NA	193	82	NA	279	119	NA	384	163	NA	501	218	724	636	278	1,144	937	408
10	NA	84	31	NA	138	56	NA	207	90	NA	299	131	NA	409	177	606	538	236	776	686	302	1,226	1,010	454
15	NA	NA	36	NA	152	67	NA	233	106	NA	334	152	523	467	212	682	611	283	874	781	365	1,374	1,156	546
20	NA	NA	41	NA	NA	75	NA	250	122	NA	368	172	565	508	243	742	668	325	955	858	419	1,513	1,286	648
30	NA	NA	NA	NA	NA	NA	NA	270	137	NA	404	198	615	564	278	816	747	381	1,062	969	496	1,702	1,473	749

50	NA	620	328	879	831	461	1,165	1,089	606	1,905	1,692	922													
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For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm², 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.

TABLE G2428.3(4) [504.3(4)]
MASONRY CHIMNEY

Number of Appliances	Two or more
Appliances Type	Category I
Appliances Vent Connection	Single-wall connector

VENT CONNECTOR CAPACITY																											
VENT HEIGHT (H) (feet)	CONNECTOR RISE (R) (feet)	SINGLE-WALL METAL VENT CONNECTOR DIAMETER (D)—inches																									
		3			4			5			6			7			8			9			10				
		APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU/H																									
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		FAN	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
6	1	NA	NA	21	NA	NA	39	NA	NA	66	179	191	100	231	271	140	292	366	200	362	474	252	499	594	316		
	2	NA	NA	28	NA	NA	52	NA	NA	84	186	227	123	239	321	172	301	432	231	373	557	299	509	696	376		
	3	NA	NA	34	NA	NA	61	134	153	97	193	258	142	247	365	202	309	491	269	381	634	348	519	793	437		
8	1	NA	NA	21	NA	NA	40	NA	NA	68	195	208	103	250	298	146	313	407	207	387	530	263	529	672	331		
	2	NA	NA	28	NA	NA	52	137	139	85	202	240	125	258	343	177	323	465	238	397	607	309	540	766	391		
	3	NA	NA	34	NA	NA	62	143	156	98	210	264	145	266	376	205	332	509	274	407	663	356	551	838	450		
10	1	NA	NA	22	NA	NA	41	130	151	70	202	225	106	267	316	151	333	434	213	410	571	273	558	727	343		
	2	NA	NA	29	NA	NA	53	136	150	86	210	255	128	276	358	181	343	489	244	420	640	317	569	813	403		
	3	NA	NA	34	97	102	62	143	166	99	217	277	147	284	389	207	352	530	279	430	694	363	580	880	459		
15	1	NA	NA	23	NA	NA	43	129	151	73	199	271	112	268	376	161	349	502	225	445	646	291	623	808	366		
	2	NA	NA	30	92	103	54	135	170	88	207	295	132	277	411	189	359	548	256	456	706	334	634	884	424		
	3	NA	NA	34	96	112	63	141	185	101	215	315	151	286	439	213	368	586	289	466	755	378	646	945	479		
20	1	NA	NA	23	87	99	45	128	167	76	197	303	117	265	425	169	345	569	235	439	734	306	614	921	347		
	2	NA	NA	30	91	111	55	134	185	90	205	325	136	274	455	195	355	610	266	450	787	348	627	986	443		
	3	NA	NA	35	96	119	64	140	199	103	213	343	154	282	481	219	365	644	298	461	831	391	639	1,042	496		

COMMON VENT CAPACITY																								
VENT HEIGHT (H) (feet)	MINIMUM INTERNAL AREA OF MASONRY CHIMNEY FLUE (square inches)																							
	12			19			28			38			50			63			78			113		
	COMBINED APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																							
	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT	FAN + FAN	FAN + NAT	NAT + NAT
6	NA	NA	25	NA	118	45	NA	176	71	NA	255	102	NA	348	142	NA	455	187	NA	579	245	NA	846	NA
8	NA	NA	28	NA	128	52	NA	190	81	NA	276	118	NA	380	162	NA	497	217	NA	633	277	1,136	928	405
10	NA	NA	31	NA	136	56	NA	205	89	NA	295	129	NA	405	175	NA	532	234	171	680	300	1,216	1,000	450
15	NA	NA	36	NA	NA	66	NA	230	105	NA	335	150	NA	400	210	677	602	280	866	772	360	1,359	1,139	540
20	NA	NA	NA	NA	NA	74	NA	247	120	NA	362	170	NA	503	240	765	661	321	947	849	415	1,495	1,264	640
30	NA	NA	NA	NA	NA	NA	NA	135	NA	398	195	NA	558	275	808	739	377	1,052	957	490	1,682	1,447	740	

50	NA	612	325	NA	821	456	1,152	1,076	600	1,879	1,672	910													
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For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm², 1 foot = 304.8 mm, 1 British thermal unit per hour = 0.2931 W.